A SYSTEMS APPROACH TO U.S. FISCAL AND MONETARY POLICIES

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(ABSTRACT)

The subject matter of this project and report is the application of systems engineering principles to this country's fiscal and monetary policies. The project demonstrates the use of systems engineering principles in the analysis of the current economic problems and in the formulation of possible solutions to these problems. A basic overview of current fiscal and monetary systems provides a foundation for understanding the problems and possible solution approaches.

Many systems engineering tools and techniques are useful in solving the nation's economic problems. Systems analyses, including verbal modeling, causal diagramming, and simulation modeling are capable of finding the root causes of current economic difficulties. The principles of life-cycle cost analysis are excellent tools for improving the federal budgetary process. Multiattribute decision analysis methods are invaluable when prioritizing competing projects. Benefit-cost analyses ensure that a given project yields benefits that are worth the cost to the taxpayers. Functional analyses and decision making techniques are useful in eliminating waste from federal agencies, and they ensure critical resources are employed in the most productive manner. Mathematical modeling techniques are used to project the results of proposed fiscal and monetary policies.

Some of these engineering tools are applied in a manner that assists officials in making informed policy decisions; others are important in exposing the structures, mechanisms, and dynamics of economic policy issues. The common factor through all of the approaches is the application of engineering principles to this national policy arena.

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1.0 Introduction

The current state of the economy is of great concern to the vast majority of U.S. citizens. The public has lost a great deal of confidence in the ability of elected and appointed government officials to formulate and execute successful fiscal and monetary policies. The troubling economic conditions and the lack of a visible, convincing economic recovery plan are recognized as principle reasons for the defeat of President Bush in the November 1992 elections. The problem of the growing national debt occupies a prominent position in the national media coverage and political debate. The time has come for a fresh, logical, systems approach to the problems of the nation's fiscal and monetary policies. According to Churchman:

> "If one steps back from this controversy and looks at the whole area in more of a total systems approach, some clarification on the issue can be developed."[1]

Systems engineering principles provide an organized, objective, and understandable method for attacking, analyzing, and solving the nation's economic problems. Too often, the current debate on the issue is clouded by irrational, emotional discourse and partisan politics. Systems engineering tools promote rational analysis and debate among professionals with diverse backgrounds and viewpoints. Systems engineering helps to uncover the root causes of problems by espousing a top-down, systems view of the fiscal and monetary policies and procedures.

1.1 Fiscal and Monetary Policies

The nation's fiscal and monetary systems and policies are quite complex; therefore, a brief overview of these topics and their histories is necessary to fully appreciate the scope of the problem. Fiscal policy refers to rules, regulations, standards, and procedures associated with formulating the annual federal budget. A goal of fiscal policy is to attempt to control the actions of individuals and corporations by means of spending and taxing decisions. Monetary policy refers to control of the supply of money. By managing its portfolio of debt, the federal government can effect interest rates, and by deciding the amount of new money injected into the economy, it can effect the amount of cash in circulation. These two major policy areas (fiscal and monetary) are essentially the federal government's "keys" to the nation's economy.

1.2 Federal Budgetary Policy

A high proportion of the nation's economic activity is controlled directly or indirectly by the various levels and forms of government. Two principal ways that government exerts this control of the economy are taxation and government borrowing. Taxation is not only used by the government to raise revenues, it is also used to redistribute income and encourage or discourage certain activities. In the United States, government borrowing has become so extensive that budgetary policy has a great influence on capital markets and on interest rates and credit availability. Taxation and borrowing are integral parts of the nation's budgetary system.

The United States currently uses a cash budget system. Advantages of a cash budget system include:

- Relative simplicity
- Very comprehensive
- Total accountability of payments by the federal government to and from the public.

Disadvantages of a cash budget system include:

- Not directly tied to government decision-making
- Liabilities are not synchronized with payments
- Appropriations relate to future rather than present activities
- Expenditures relate from past rather than present decisions.

Other budgetary methods exist and have been tried in the United States. The Carter Administration selectively tried a system called zero-base budgeting in the 1970s. In the current cash budget system, the year-to-year budgetary debate focuses primarily on incremental spending within programs. With zero-base budgeting, the entire program is re-evaluated each year. This system was largely ineffective. It was overcome by years of bureaucratic inertia and the vested interests of huge, powerful, government organizations.

Another budget concept is the full-employment budget. This type of budget is based on receipts and expenditures that would exist under conditions of full employment. The actual receipts and expenditures are of secondary importance. The influence of the budgetary process on the national economy is the principal concern. For instance, if the nation is actually falling short of full employment, a budget deficit is likely to be prescribed under a full-employment budget system. The reasons for the deficit are very simple. First of all, the unemployed population contributes less revenues in the form of income taxes. Secondly, the unemployed population requires more government spending in the form of entitlements. And thirdly, a condition of high unemployment is likely to contribute to an atmosphere of reduced economic activity. The full-employment budget is designed to help spend the nation out of unemployment difficulties and provide federal assistance to the public when it is needed most. The current U.S. budget has many characteristics of a full-employment budget system.

1.3 Budgetary Planning

Budgetary planning under the current U.S. system is fraught with many difficulties and uncertainties. The budget is based on the projected cash expenditures on the programs and services in question. The future cost of many programs is difficult to project due to long program lives and pricing and economic fluctuations. Additionally, many expenditures (particularly entitlements) cannot be budgeted on a cash basis because the programs in question are legislated. That is, an indefinite segment of the population is entitled to a portion of a program's expenditures.

Since budgeting is done on an incremental rather than a zero-base fashion, perverse incentives are created. Government managers have a disincentive to save. For instance, if a manager "gives back" some of his incremental allocation this year, he may be forced to suffer a reduced allocation next year when he may really need more funds.

1.4 U.S. Budget Composition

The U.S. budget contains detailed information on intended outlays and expected receipts. Outlays are divided into two components: (1) those items that can be carried out without further Congressional action, and (2) those items that require further authorization to actually spend the funds. Each of these components is typically about 50 percent of the budget. The budget also summarizes the current assessment of the national debt and budget deficit.

The actual government expenditures may be divided into two main categories: (1) government purchase of goods and services for public benefit, such as education health, and defense, and (2) payments of social security and other entitlements to individuals, and subsidies to agriculture and selected industries. This latter expenditure category is known as transfer payments.

In addition to direct expenditures, there also exists tax expenditures. Tax expenditures are tax credits or reductions that are designed to stimulate or encourage certain activities or actions.

1.5 The Systems Approach

The remainder of this paper delves more deeply into fiscal and monetary policies and problems, and it explains the use of specific industrial and systems engineering tools and techniques to analyze and solve these problems. This approach reveals the root cause of some fundamental flaws in the nation's economic system and illustrates some feasible solutions. System life-cycle cost analysis, multiattribute decision analysis, functional analysis, modeling, and benefit-cost analysis are proposed as tools to help the nation's policy-makers to make logical policy decisions. System dynamics techniques are used to add understanding to the structure of problems. Simulation modeling is a means to forecast future conditions and test proposed problem solutions. The common thread through all of these tools and techniques is a top-down, systems approach to the situation.

2.0 Review of Literature

This project necessitated a significant amount of research into current thoughts on the state of the nation's fiscal and economic systems and policies. The most provocative and interesting sources that were encountered are tied to the original impetus for the topic of this project and report.

This project was inspired by an article in the Winter 1993 edition of The Bent of Tau Beta Pi written by Theodore R. Thoren. The article is entitled, "Space-Age Technology Can Correct the Money System." The article calls for a logical, methodical, engineering approach to the nation's economic problems. For additional reading on the topic, Mr. Thoren cites a book that he co-wrote with Richard F. Warner called The Truth In Money Book. Their book is even more fascinating than Mr. Thoren's article. It presents thorough explanations of many of the nation's economic problems. A central theme to the book is that if advanced engineering principles can be used to solve such technically complex problems as placing a man on the moon, then surely a similar engineering approach can be used to solve the nation's economic problems. Additionally, they actually propose the Treasury Credit Money System as a solution to the nation's debt and inflation problems. A central premise to the Treasury Credit Money System is the shift of the national monetary authority from the Federal Reserve to the Treasury.

Engineering literature is also important to the success of this project. Accordingly, systems engineering, systems dynamics, and engineering economic analysis texts are referenced throughout.

3.0 Materials and Methods

This project draws on the methods of several engineering courses taken at the Virginia Polytechnic Institute and State University. The project is an attempt to tie several engineering concepts together and apply these concepts in a troubled field where they may be able to make a significant contribution. A review of candidate engineering methods for application to fiscal and monetary policy narrowed the field to those methods presented in this paper. In essence, a miniature feasibility study was performed on the many engineering methods available to determine which methods were most applicable and most likely to contribute in a significant manner. Of particular interest is the field of system dynamics and the application of system dynamics to Thoren and Warner's Treasury Credit Money System.

Several types of computer applications were also used in the course of this project. The Automan multiattribute decision analysis tool is demonstrated for a policy-making type of application. System dynamics equations were imbedded in the Microsoft Excel spreadsheet to demonstrate the use of the system dynamics methodology. This spreadsheet is particularly useful in that it contains a very flexible chart-making tool.

4.0 Results

The principle result of this project is the demonstration of the broad applicability of systems engineering principles and methods. The project brings engineering into a domain where it is not often seen, the nation's fiscal and monetary policies. Perhaps it is the lack of a systems approach to economic policy that has gotten the country into the difficulties that it faces today.

In particular, the project shows how systems engineering principles can be utilized by policy makers to effectively control the budgetary process. A systems approach to the budget helps decision makers ensure that they receive the best product that they can. Methods such as system functional analysis, decision modeling, multiattribute decision analysis, and life-cycle cost analysis can be effectively used to enhance the budget process. A systems approach to revenues illustrates the causal relationships in this complex system.

System dynamics methods, including verbal models, causal diagrams, and simulation models are useful in another type of economic situation, policy formulation. System dynamics shows in a striking manner how the nation's current fiscal and monetary policies lead to an explosion in the national debt. The method also shows how a change in policy to a system called the Treasury Credit Money System can lead to the elimination of the debt in just several years.

5.0 Discussion

The frequency of money system problems in otherwise successful societies is one of the major economic issues of the modern age. The U.S. economy has experienced six major downturns since the early 1900s. To a systems engineer, the recurring difficulties indicate a serious design problem. Instead of propping-up the same failed system time and again, the systems approach dictates the incorporation of some new designs, or possibly a complete overhaul of the system from the top-down.[2]

Engineers can contribute a logical, broad, systems approach to the nation's economic difficulties. In the Fall 1990 issue of The Bent of Tau Beta Pi, Dr. John H. Sununu, then White House Chief-of-Staff, wrote:

> "... engineers bring to the policy making process a
> well-honed capacity to solve problems."[3]

This systems-oriented, problem-solving capacity can provide a new focus on the nation's economic problems. A detailed review of the current policies can uncover areas where applied systems engineering may make the most significant improvements. System dynamics and analysis can uncover the root causes of systemic problems. Systems engineering methods can be used to incorporate new designs into fiscal and monetary policies. Finally, a systems approach can be used to completely overhaul the nation's fiscal and monetary systems.

The first step in using systems engineering to help solve the nation's economic woes is to take a detailed look at the current economic system. A working knowledge of the current economic system and an understanding of the current problems are indispensable. The nation's political system also compounds the complexity of the economic system, and the astute systems engineer must account for this added complexity when formulating solutions to problems. A proposed solution is worthless if it is not politically tenable. Once the current system is fully understood, systems tools and procedures are used to (1) "fix" problems within the current system by incorporating new designs and methodologies, or (2) redesign the system in light of past failures and difficulties.

5.1 The Growth of Public Expenditure

Public expenditure has grown dramatically during the latter half of the twentieth century for three main reasons:

1. The major growth of defense expenditures, including the rising costs of veteran's pensions and benefits.
2. The increased administrative role of government in response to an expanded, urbanized, and aging population.
3. The increase in demand for public services as the vote was extended to lower economic classes.

In the United States, overall public expenditure as a percentage of gross domestic product (GDP) has grown substantially since World War II. Transfer payments (redistribution of wealth) as a proportion of national income have grown even faster than gross public expenditure.

Transfer payments, part of which is Social Security, are highly dependent on the proportion of elderly and unemployed in society. Aside from cutting back on benefits or establishing an economic policy designed to reduce unemployment, very little can be done to limit transfer payments. Additionally, a reduction in benefits may require the passage of legislation, particularly in the case of entitlement programs.

Public sector purchasing practices have also contributed to the growth of public expenditure. Public sector purchasing may be inefficient (particularly with respect to defense spending) as administrators demand the latest technologies without regard for cost-effectiveness. The public sector also lacks incentives to increase efficiency and productivity that apply to private firms in competitive markets.

Public sector bureaucracy has also contributed to the growth of expenditures. In bureaucracies, managers may feel that it is more important to avoid mistakes than to experiment with new techniques and procedures. The decision to stay the course is often far less risky than taking a chance on a new idea, even if the idea shows promise. Thus, an atmosphere of stagnation may develop that ultimately prevents new ideas from even being proposed. Managers may end up devoting more of their time and staff to the pursuit of administrative burdens designed to cover their every move than to actually producing the service that is their true mission. This type of attitude has also led to the tremendous growth of government staffs, and since the government does not have a profit motive, it also has no real incentive for personnel efficiency.

The net effect of public sector bureaucracy and inefficiency is rather troubling; coupled with technological advance, there has been a general tendency for expenditures to rise without an apparent increase in service. In fact, in many areas, as expenditures have risen, the public has perceived an actual decrease in the quality and quantity of service. This is particularly true in areas such as education and urban development.

5.2 A Systems Look at Revenues

A systems engineering view is helpful in understanding the method by which the government takes in money to sustain itself. The systems engineer is particularly interested in causality, or what makes "something" behave as "it" does. Causality is integral to the system dynamics process, which is covered in depth in another section of this paper. An introduction to causality is very appropriate at this point to show how the revenue subsystem behaves at a high level.

5.2.1 Causality

Causality refers to the cause-and-effect relationships that are part of any dynamic system. Causal relationships among variables often form a loop by closing on themselves. This loop is known as a feedback loop. Within a feedback loop, a change in any variable ripples through all other interconnected variables until the original variable itself is indirectly effected by its own perturbation. Feedback loops are characterized as positive or negative. In a positive feedback loop, a change in a variable is reinforced in the same direction as the original change, which leads to sustained growth or decline. In a negative feedback loop, a change in a variable is resisted or countered, which leads to fluctuation or a tendency toward an equilibrium.[4]

5.2.2 Causal Diagrams

An important tool for demonstrating causality is the causal diagram. To construct a causal diagram, the key variables of a system or subsystem are identified in a verbal description. The key variables are connected in pairs by arrows. The direction of the arrow indicates the direction of causation. The variable at the head of the arrow is the dependent variable (the variable being effected); the variable at the tail of the arrow is the independent variable (the variable creating the effect).[5] Causal diagramming is also treated in greater detail in a section on system dynamics.

5.2.3 Taxation and Causal Relationships

The causal relationships in the revenue process are very interesting and somewhat paradoxical. One of the major sources of federal revenue is the federal income tax. The initial effect of a tax rate *increase* is an *increase* in revenues. However, experience has also shown that an *increase* in tax rates tends to *reduce* work effort, which in turn tends to *reduce* tax revenues. A *reduction* in revenues may require an *increase* in the tax rates. The net effect is indeterminate without performing some type of systems-level quantitative analysis. A basic causal diagram of this small subsystem is shown in Figure 1. The plus and minus signs at the arrow heads indicate the direction or polarity of the cause and effect relationship.

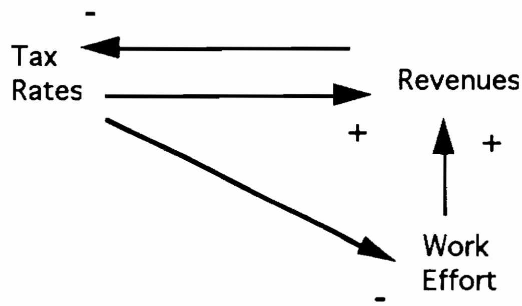

Figure 1. Revenue causal diagram.

At some level of taxation, the disincentive to work effort becomes so great that any increase in taxation will actually reduce the net revenue. The Reagan Administration attempted to increase tax revenues by stimulating the economy with a tax rate reduction. The economy was stimulated to impressive growth, but expenditures grew even more, which caused an increase in the federal deficit. The net effect of the Reagan Administration policies is still being debated by economists and politicians today.

Tax rates effect the pattern and level of consumption. Excise taxes, sales taxes, and value-added taxes (VAT) all change the relative prices of goods and services and the attractiveness of spending versus saving. Once again, an increase in the tax rates (in this case, the consumer tax rate) tends to generate behavior (saving instead of spending) that acts to reduce tax revenues. An example that has been recently cited in the media is the effect of the yacht and luxury car excise tax. Consumers either postponed purchases or made purchases that were not subject to the tax (for example, used luxury cars). The net effect has been the generation of a modest amount of revenue at the expense of the decimation of the domestic yacht industry. Perhaps the politicians who passed this law did not consider a systems approach to the issue.

Tax rates also effect commercial business decisions. Therefore, a proper balance between corporate and personal taxes must be found. An excess corporate tax burden retards business growth, adversely impacts U.S. corporations' international competitiveness, and inhibits entrepreneurial activity such as new business ventures. The detrimental effects to business of excess taxation ultimately impacts the individual.

Individual investment decisions are also impacted by tax rates. As tax rates are increased, individuals go to greater and greater lengths to shelter their incomes and assets from taxation. Consequently, as tax rates rise, tax payers invest in capital-generating rather than income-generating ventures since capital gains are not taxed until the investment is disposed of, and the maximum capital gains tax rate has been historically lower that the maximum ordinary income tax rate. Increases in tax rates also stimulate tax-sheltered, overseas investments.

5.3 Government Borrowing

Historically, when a government does not take in enough money in revenues to pay for its spending and obligations, it must resort to borrowing. For the most part, public debt differs from private debt only in that it is an obligation of the government rather than an individual or corporation. Public debt is classified according to four basic categories:

1. Internal versus external: if the debt is held within the issuing jurisdiction, it is internal debt.
2. Maturity period: if the maturity date is within five years, the debt is short-term or floating debt; if the maturity term is longer than five years, the debt is known as long-term or funded debt.
3. Type of issue: depends on whether the debt is issued directly by the government or by a semi-autonomous government agency.
4. Marketability: most debt is marketable, some debt, such as U.S. Saving Bonds, is not marketable.

5.3.1 Effects of Borrowing

When the government obtains its funds from the central bank (the Federal Reserve System), it is really creating money rather than borrowing it, since the purchasing power is made by the central bank and no obligations to the public are created - at least not directly. The money is created as a debt, and the public must eventually repay this debt, plus interest, through taxation. This system of creating new money as a debt is known as a debt money system.[6] The debt money system is treated in great detail in a later section.

When government borrows money, funds are transferred from the lender to the government. Funds that are loaned to the government usually come from savings, as opposed to funds that are paid in taxes, which more likely come out of consumption. To pay an increase in taxes, most individuals are forced to reduce consumption, since they have little or no margin of safety, and they do not want to incur greater indebtedness. Those who a have a comfortable margin of safety may reduce consumption voluntarily because they want to keep their savings intact. Lending, on the other hand, is entirely a matter of choice. The individual who buys government securities is not likely to increase his savings rate or reduce consumption. If government borrowing increases the market rate of interest, the individual may divert a small additional amount to savings, but this effect is relatively minor.

The net effect of government borrowing on total spending and thus, employment and national income, depends upon its influence on real investment - the purchase of new capital goods. Once again, a broad, quantitative, systems view of causality is required to determine the ultimate result. In periods of full employment, with banks loaned to the limits of their reserves and real investment absorbing all savings, additional government borrowing will restrict private spending in much the same manner as an increase in taxation under the same conditions. In periods of unemployment, savings are available at a quantity greater than that required for investment; therefore, government borrowing does not compete with private investment or make it more costly. In effect, the government absorbs and spends funds that would otherwise be idle.

Government borrowing has other significance:

1. The buying and selling of government securities provides the central bank with a means of influencing money supply, which is essential for the implementation of an effective monetary policy.

2. Borrowing avoids the adverse effects that taxes may have on incentives (in the short-term, that is - the debt must still be paid be the tax payer eventually).

3. Borrowing permits government expenditures to be higher than would otherwise be feasible (under the current economic system).

The aforementioned effects of government borrowing are viewed from within the current paradigm. A later section demonstrates that alternatives to the current system exist in which high levels of government borrowing are not required or even desired.

5.3.2 Effects of Government Debt

Individuals who hold government securities regard them as a portion of their wealth - even though the only way the government can repay the debt is by taxing the individuals who hold the debt. In other words, "We owe it to ourselves." Until recently, this link in causality was not readily apparent. The recent attention to the national debt has increased the public's awareness to all facets of this problem. In the past, the existence of the debt tended to cause individuals to spend more and save less than they would have if they had fully understood the link between the "debt" and the "debtor". The additional consumption had a tendency to reduce the rate of capital investment and retard economic growth; it may also have contributed to an increase in unemployment. The period of tremendous growth of the national debt in the 1980s stands as evidence to these postulates. Consumption was very high throughout the 1980s as consumer debt swelled. The decline of the nation's manufacturing sector and the deterioration of the nation's urban areas and infrastructure point to a lack of capital investment.

Government securities, which are the product of government borrowing, also affect the economy. Since government securities are more liquid than other investments, their holders are able to increase consumption out of accumulated savings. This increase in consumption may contribute to the rate of inflation. Additionally, during periods of full employment, increases in government expenditures that are not offset by decreases in private spending tend to be inflationary. However, the section on the debt money system fully explains how public and private debt are inherently even greater causes of inflation.

The government debt also impacts commercial business in important ways. If the business community and its investors regard the national debt as a potential source of economic instability, they will be less likely to undertake capital and entrepreneurial investment. If government spending causes a large proportion of available funds to be spent on the public debt, the amount of funds available for private investment is reduced. This reduction in capital supply causes an increase in interest rates as the government competes with the private sector for available funds.

The interest burden of the national debt is another consequence of borrowing. As this interest burden mounts, taxes must be increased or spending on other activities must be reduced. This is currently the situation in the United States, where President Clinton's economic plan calls for a reduction in spending in many areas, plus an increase in certain taxes to fund economic recovery investments.

5.3.3 Debt Retirement

If the government debt is retired from increased tax revenues, private consumption is likely to be reduced. Any tax that is not offset by a reduction in consumption is paid out of savings, which tends to reduce real investment. The net reduction in spending due to debt retirement is likely to reduce overall economic activity. Current taxes are increased as previously stated, and future tax obligations are reduced.

5.4 The Budgetary Process

The executive and legislative branches of the federal government together formulate a coherent set of tax and spend proposals. The federal budget is not like a commercial business budget. The federal government is not held to the same high accounting standards with which private businesses must comply; the federal budget is generally regarded as being of a lower quality than a typical private sector budget. In the federal budget process, forecasts of receipts and expenditures are quite often remarkably different from reality.

5.4.1 U.S. Budget Basics

Since 1921, the U.S. federal budget has been the responsibility of the President. The budget is prepared by the Office of Management and Budget (OMB) under his authority. The various departments and agencies of the federal government submit appropriation requests to the OMB. The OMB compiles the inputs and assembles them into one budget. The U.S. budget deals mainly with expenditures; revenues are treated with much less detail.

After the President approves the budget, it is forwarded to the House of Representatives. Here, the budget is disassembled much the same way that the OMB assembled it. The various parts of the budget are given to corresponding subcommittees of the Appropriations Committee. The budget is not considered as a whole by the committee as a whole. Revenues fall under the purview of the House Ways and Means Committee, and they are considered separately from appropriations. The Senate plays a less significant role in the budgetary process. The Senate's Appropriation Committee acts as a sort of appellate court with respect to the House Appropriation Committee.

In January of each year, the President submits three documents to the Congress:

1. The State of the Union Message
2. The Federal Budget
3. The Economic Report.

The Economic Report is the administration's assessment of the economic impact of the budget. Included in this document are projections of the budget's effect on employment and prices.

An important aspect of the budgetary process is the fact that no formal procedure exists for ensuring that competing interests are considered fairly or that some form of balance is struck. The process is very much a battle of political power, partisanship, constituencies, and special interests. The satisfactory outcome of the budgetary process depends to a great extent upon how well the competing powers are balanced. This is not to say that the current process cannot be improved by the application of systems engineering and analysis principles.

5.4.2 A Systems Approach to the Budgetary Process

Program planning and budgeting (PPB) is a systems planning and budgetary technique that was pioneered in the Department of Defense (DOD). The DOD has used PPB techniques to prioritize and allocate scarce financial resources in the most productive manner with respect to the defense mission. The remainder of the federal government can also use PPB principles in the federal budgetary process.[7]

The first step in using PPB is to break a program down into subprograms. The goal is to break a large, cumbersome budget item down into segments to which resources can reasonably allocated and assessed. Next a matrix is formed with government entities along one axis and programs or subprograms along the other axis. Initially, simple check marks are shown in the blocks of the matrix to show an activity or correlation. Then, the check marks are replaced by dollars or some other measure of effectiveness (MOE).

As a simple example, consider the matrix shown as Table 1. In this matrix a fictitious federal drug policy is broken down into four subprograms (1) interdiction, (2) enforcement, (3) treatment, and (4) education. The federal government is broken down into eight entities that have some connection to the federal drug policy plus an additional "dummy" entity that represents federal drug aid to state and local governments.

Table 1. Initial PPB matrix.

	Interdiction	Enforcement	Treatment	Education
DOD	√			√
Coast Guard	√	√		
Justice		√		
ATF		√		
DEA	√	√		
HUD			√	
HHS			√	√
Immigration	√	√		√
State & Local		√	√	√

5.4.2.1 Politics and the Systems Approach

The next step is to replace the check marks in the matrix with dollar amounts or some other MOE. At this point, the systems engineer would like the allocation of resources to reflect how they are truly spent or consumed, but this could be difficult politically. The engineer may well believe that the assignment of numbers to the matrix should be an objective procedure. Referring to the example, the larger political system is corrupting the drug policy subsystem or subprogram. Political negotiation is then required to assign numbers to the matrix.

The systems engineer may be uncomfortable at this point because he may rightly believe that the systems approach is straightforward and presents a logical method of budgetary decision making. The engineer may reasonably feel that political negotiation and maneuvering can only detract from the systems approach and that the systems approach is designed to eliminate subjective, emotional aspects of decision making. The engineer's need to be feasible, not just theoretical, prevents him from simply throwing up his hands at this point.

The astute systems engineer will see some advantage in the political side of budget making. In fact, the systems approach provides a useful and important framework for political debate. Instead of debating only on the ultimate, high-level policies as is often done in the Capitol today, the systems approach carries the debate down to the sub-policies, elements, and sub-elements of the issues. The policies and alternatives can be defined in a top-down fashion, and then they can be debated on a more detailed, logical level, assembled, and flowed up into the ultimate final policy. Figure 2 is a graphical representation of the division of policies in a top-down fashion for the purposes of debate and decision making. This policy debate structure enables the systems engineer to become an integral and important part of the political budgetary system rather than remain as an outsider.

The process of debate leads back to the matrix that still requires some type of MOE to be added. Two very important questions about the MOE allocation process must be resolved:

1. How are the "numbers" ultimately resolved?
2. Who has the responsibility and authority for assigning the numbers?

The various agency heads certainly cannot be objective about this process, so they should not have this responsibility. The public surely cannot get directly involved in such an immense activity. Perhaps the most logical choice is an independent inspector or auditor with a systems engineering organization as a consultant.

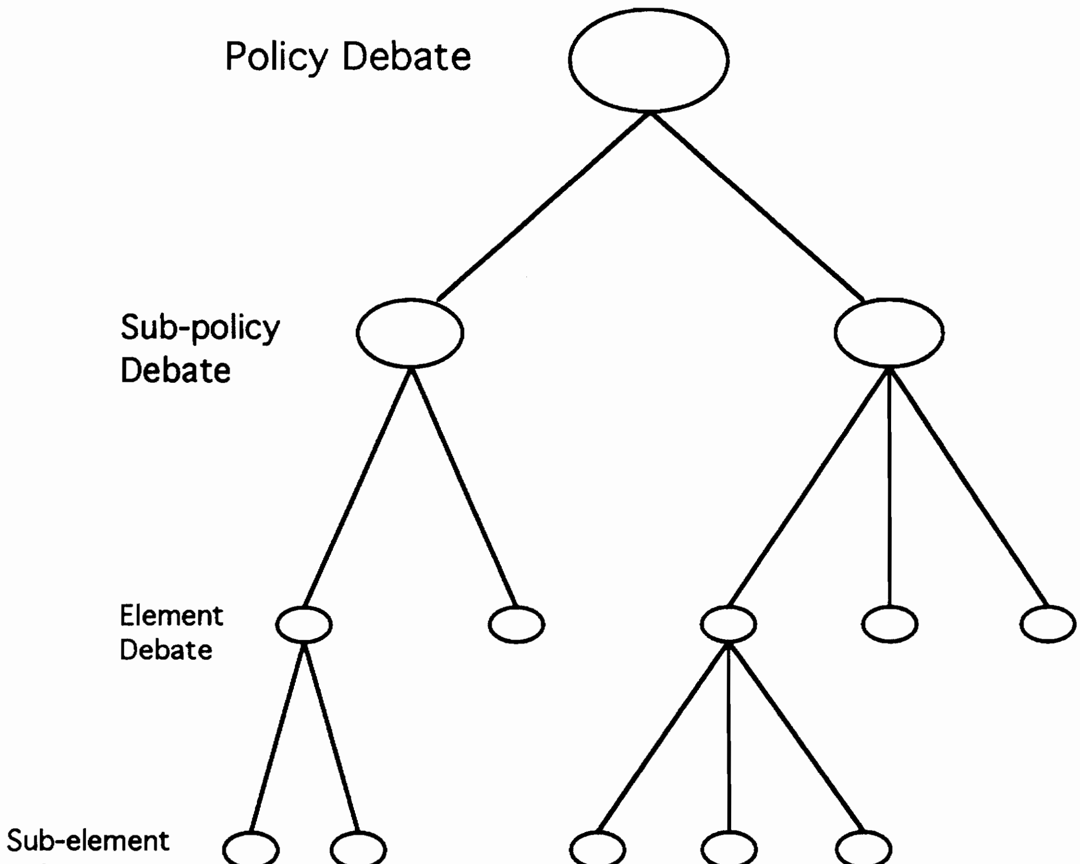

Figure 2. Policy debate structure.

5.4.2.2 Data Collection

The systems engineer now has a rather familiar challenge. He needs data to assess the performance and activities of the sub-programs, elements, and sub-elements. In order to obtain such data objectively, he must understand the whole system. To understand the whole system, the systems engineer must perform a top-down, systems analysis.

The engineer can view the political debate as a type of estimating procedure through which data are obtained. In fact, the systems engineer may design debate and negotiation into the system to help uncover the data most important to the systems analysis. The debate function would be designed to bring to light the true issues of the system, subsystem, elements, and sub-elements.

The systems engineering approach involves a display of design alternatives through debate and then the selection of the best design in light of system objectives and functions. The idea of debate and alternatives also applies to the method by which data are selected for use by systems engineers and decision makers. A system as large and complex as the budgetary process requires significant planning and replanning and checking of data against preliminary assumptions.

5.4.2.3 Budgetary Allocations Versus Demands

In order to finish the budgetary analysis, another matrix is required. The entries in this matrix represent demands made on the various programs of the mission by various types of "customers" or users. The matrix is filled in with available data such as total number of hours required or devoted that aspect of the mission and that customer. The end result of this process is a requirements matrix that shows how the expenditure of limited funds may be logically and functionally allocated. An example of this second type of matrix is shown as Table 2.

Table 2. PPB requirements matrix.

	Interdiction	Enforcement	Treatment	Education
School Students			# Hours	# Hours
Pregnant Women			# Hours	# Hours
Urban Population		# Hours	# Hours	# Hours
General Pop.		# Hours	# Hours	# Hours
Welfare Rec.			# Hours	# Hours
Border States	# Hours	# Hours	# Hours	# Hours

The two matrices are an estimate of the effectiveness of the system. For example, if the data show that real demand for a particular program is high compared to other programs, but that funding is low compared to other programs, then a possible problem with resource allocation exists. In the actual practice of PPB, the requirements matrix is compared with the activities matrix to assess the costs and benefits of each activity.

5.4.2.4 PPB and Further Studies

One particular advantage to using PPB is that the problems and inadequacies of the current budget system will be brought to light. The public will see the lack of valid information with which elected officials must cope in making important budget decisions. The systems approach reveals gaps in knowledge or understanding of "the system" in a very logical and structured manner.

The knowledge gaps define areas of useful further research, and thus, define specific problem solving efforts that should be undertaken. Then, instead of funding research on subjects like "how to grow citrus orchards in a steppe climate", the federal government can fund studies that provide solutions to real problems.[8] The systems approach provides a logical framework for illuminating problems.

The systems approach should become an integral part of the federal research program, whereby the amounts and types of research undertaken are determined by systems analysis. A large amount of the current federal research budget is allocated to technology development; it may be appropriate to channel some of these funds to current problem solution. Since much of the federal budget is related to and expended on social programs, much of the budgetary systems research will necessarily be social research. Much public skepticism exists in this area because so much of current social research is conducted in a disjointed manner that appears to have no real focus. The systems approach provides this focus as an outgrowth of its problem solving activities. The systems approach can demonstrate to the public that there is a logical, coherent plan for solving the problems of the budget system.

5.4.3 Engineering Methods and the Budget Process

Many systems engineering and engineering economic analysis methods are useful in reforming the federal budget process. One of the key points to this argument is the fact that the number of potential applications of systems engineering principles within the federal government is almost endless, particularly with respect to procurement decisions. A good argument can be made for a regulation that calls for every government agency involved in procurement to have a systems engineering organization at its disposal. A good systems engineering organization can ensure that a government agency receives what it needs and wants, receives it on time, and procures it in as economic a fashion as possible.

5.4.3.1 System Functional Analysis

System functional analysis should occur very early in any system's design or procurement. System functional analysis helps to ensure that:

- All aspects of system development, operation, and support are thoroughly considered
- All elements of the system are fully defined
- Proper design relationships are established.[9]

The bottom line is that a functional analysis ensures that the government procurement agency knows exactly what it wants and that the chosen supplier delivers it. The agency may even perform a functional analysis on itself to ensure that it is delivering what its charter specifies and that no wasteful, useless, bureaucratic inefficiencies are present.

An important part of a successful functional analysis is the functional flow diagram. The purpose of a functional flow diagram is to structure system operational and maintenance requirements into functional terms. In the words of Blanchard and Fabrycky:

> "...not one piece of equipment should be defined or acquired without first justifying its need through the functional requirements definition process."[10]

Imagine the savings to the taxpayer if every single line item on the federal budget was *required* to pass this test.

5.4.3.2 Decision Making Models and Alternatives

The decision maker has many models and tools available to assist in the identification and evaluation of alternatives. Models have great economic importance in that a model can be changed, manipulated, and redesigned much more quickly and economically than a real system. Models also help to reduce some of the risk of decision making.

Models may be classified as physical, analog, verbal, schematic, and mathematical. Verbal, schematic and mathematical models have the highest degree of applicability to the budgetary decision process. A verbal model is a written or oral description of the system. A verbal description is often the starting point in the modeling process. A schematic model is obtained by reducing a system to a chart or diagram. A causal diagram (such as Figure 1) is a good example of a type of schematic model. Mathematical models use equations to represent the system being studied, and their use is very common in prediction or control applications. A mathematical model may be as simple as an annual cost analysis of a small, straightforward expenditure, or it may be as complicated as the simulation models used in system dynamics. System dynamics theory uses verbal models, causal diagrams, and complex mathematical models to predict the behavior of a system over time. System dynamics modeling is covered in depth in a later section.

Another type of mathematical model is the decision evaluation function. A decision evaluation function formally links the evaluation measure or MOE with controllable decision variables and uncontrollable system parameters. The decision evaluation function is represented by

$$E=f(X,Y), \tag{1}$$

where E is the evaluation measure, X represents the decision variables, and Y represents the system parameters. Equation 1 represents the decision evaluation in its unconstrained form. However, the system may be subject to a set of certain constraints. Constraints are expressed as functions of decision variables, system parameters and constant constraints. The constraint function is given by

$$g(X,Y)=C, \tag{2}$$

where C is the constant constraint and the equality may be replaced by $\leq$ or $\geq$. Several variations of the decision evaluation function exist as the general form has been customized to specific applications. The decision evaluation function allows the policy maker to test different values of decision variables, X, in the presence of system parameters, Y, subject to constraints, C, to determine which course of action results in the most favorable outcome, E. Optimization techniques may also be used to determine what values of decision variables result in the optimum MOE.

The fiscal policy process involves almost constant decision making. In order to make the most informed decisions, the policy maker must ensure that any model that is used is appropriate for the particular situation and that alternatives are compared on equal footing. Alternatives must be converted to a common measure in order to compare them equivalently. For instance, if a budgetary policy maker is comparing projects with differing life spans, he must convert them to some type of time equivalence. He must compare them either on an annual basis, or he must compare them over a period equal to the least common multiple of the individual life spans. Only then can he make a fair judgment between the projects.

5.4.3.3 Multiattribute Decision Analysis

In many cases, the decision process evolves beyond simple comparisons of a single MOE. In some instances, the alternatives' costs are so similar that their economic differences become trivial. In other cases, costs and benefits are not easily or objectively quantifiable. In still others, multiple MOEs are present, and different MOEs favor different alternatives. In all of the above situations, multiattribute decision analysis can be used to help the decision maker sort through the complexity to arrive at a logical, reasoned decision.

Multiattribute decision analysis is actually comprised of a number of different techniques that force the quantification of multiple MOEs to arrive at a decision between alternatives. Some advantages of multiattribute decision analysis include:

- Forcing a focus on objectives, alternatives, attributes, and risks
- Facilitation of communication between experts, engineers, analysts, and decision makers
- Promoting more reasoned and logical estimating procedures
- Stimulating the generation of new alternatives
- Selling a recommendation through the communication of a logical, rational decision process.[11]

These advantages make multiattribute decision analysis an attractive tool for evaluating many budget problems and issues.

Several topics are particularly suited to multiattribute decision analysis. For instance, many aspects of the DOD budget are not easily quantifiable, particularly in monetary terms. Multiattribute decision analysis can help bring a focus on attributes that discriminate one defense budget alternative from another, which is particularly useful in this era of defense downsizing. The current issues concerning a national health care plan are another excellent application for this tool. What issues are more difficult to quantify, particularly in economic terms, than health and life? A third application that is ideally suited for multiattribute decision analysis is the rationing of limited resources associated with a national education plan.

5.4.3.3.1 General Approach

A vitally important step in the multiattribute decision analysis process is the selection of the attributes to be included in the model. This step has a profound impact on the ultimate outcome of the process. Obviously, the attributes viewed as the most important in the decision making process should be included. Care should be taken to ensure that all of the attributes finally selected are independent of one another. There is no particular ideal number of attributes. The analyst should select all of the independent attributes that have a reasonable chance of affecting the outcome of the decision. If too few attributes are selected, some important ones are left out; if too many are selected, the analysis is bogged down in trivial details.[12]

Once the attributes are selected, the particular type of analysis is chosen. Several methods and presentations of multiattribute decision analysis have been developed with varying degrees of complexity and detail. The ultimate choice of the form of the analysis depends on the situation and the preferences of the analyst.

5.4.3.3.2 Sequential Elimination Methods

These methods are useful when all attributes for all alternatives can be specified by a numerical value or rank. Sequential elimination does not take into account any weighting of attributes. The procedure is rather straightforward. Once the values are determined for each alternative, the alternatives are compared against one another or a standard. A scoring or elimination scheme is used to determine the most preferable alternative.

5.4.3.3.3 Graphical Techniques

Graphical techniques are excellent for a presentation-type environment because they make a powerful visual statement. Numerous graphical techniques are available such as shaded circles and polar graphs. With the shaded circle method, each attribute of each alternative is graphed using a shaded circle. The degree of shading depends on that alternative's performance with respect to that particular attribute. The best alternative is the one with the most shading across all attributes. Figure 3 is a basic example of the shaded circle method applied to a national health care plan. Alternative B is clearly superior.

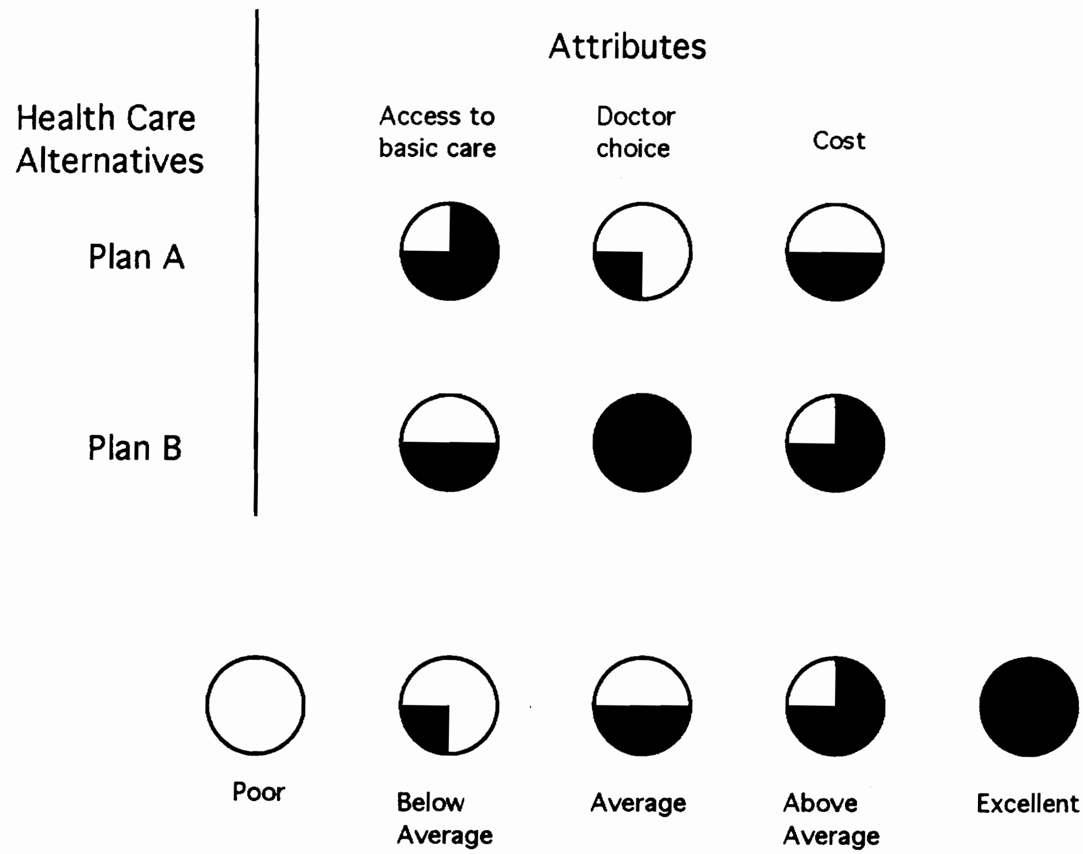

Figure 3. Shaded circle method.

In the polar graph method, a circle is drawn with a radial scale for each attribute. Each alternative's score is plotted on the radial scale for each attribute. After an alternative's score is plotted for all of its attributes, the points are connected to form a polyhedron. The relative sizes of the polyhedrons help to judge which is the more preferable alternative. Figure 4 is an example of polar graphing. In this case, Alternative 1 is more preferable.

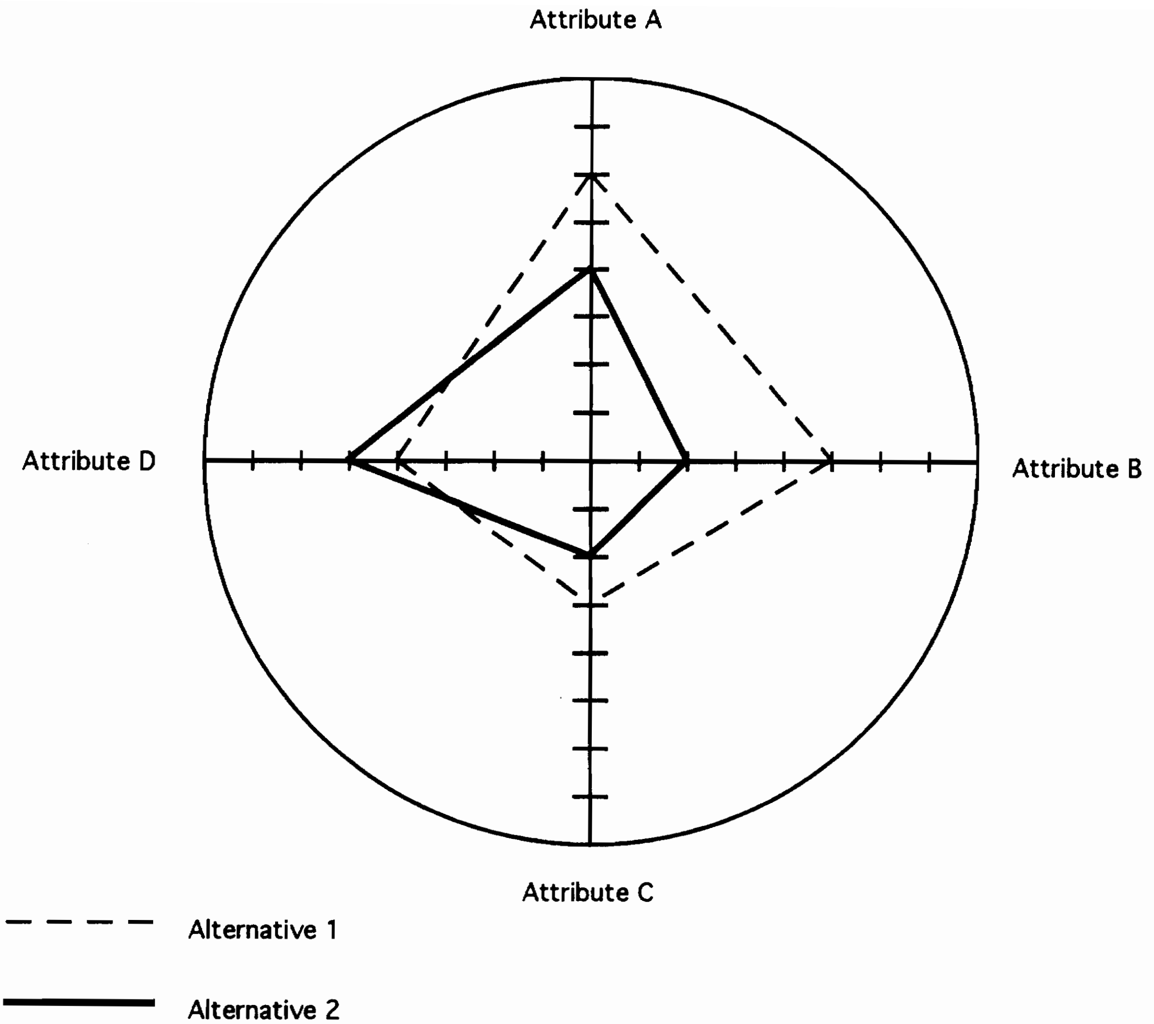

Figure 4. Polar graphing method.

In neither of these graphical methods are the attributes weighted in any manner. All attributes are considered as being equally important, which must be remembered when making a decision based on these methods. If some attributes require weighting due to their importance, one of the weighted evaluation techniques should be used.

5.4.3.3.4 Weighted Evaluation

The first step involved in making a weighted evaluation is the quantification of the relative importance of all of the attributes. All of the attributes are ranked according to decreasing preference or importance. Next, actual weights are assigned to the attributes. This assignment may be done by comparing attributes by rank and subjectively assigning values. An easier method is to use a formula to decide the weights. A common weighting formula is called the rank sum weight, which is given by

$$W_i = \frac{N-R_i+1}{\sum_{i=1}^{N}(N-R_i+1)} x100\%, \tag{3}$$

where W_i is the rank sum weight of attribute i, R_i is the rank position of attribute i, and N is the number of attributes. As an example, if 5 attributes are chosen, Equation 3 yields weights of 33, 27, 20, 13, and 7 for ranks 1 through 5. Since Equation 3 normalizes the weights, they add up to a total of 100. Other weighting formulas are also available.

Once weights are assigned to the attributes, the next step is to assign values to each alternative corresponding to the degree to which that alternative satisfies each attribute. This is generally a difficult process. A convenient method is to score each alternative on a 0 to 10 scale for each attribute. Next an alternative's score for each attribute is multiplied by the attribute's weight, which results in a weighted evaluation for the attribute. Finally, an alternative's weighted evaluations are summed across all attributes, which yields a total weighted evaluation for that alternative. Thus, if an alternative *completely* satisfies each attribute (which is very unlikely), that alternative receives a total score of 100.

Additional variations of the basic multiattribute decision analysis techniques exist. The particular variation used should be tailored to the situation. The important point is that such analyses are clearly a means of identifying, quantifying, and forcing the debate of the salient points of issues.

5.4.3.3.5 The Analytic Hierarchy Process

The analytic hierarchy process (AHP) was developed chiefly by Thomas Saaty.[13] It is an advanced form of multiattribute decision analysis that is capable of structuring very complex problems in a hierarchical fashion. This tool involves the pairwise comparison of elements (attributes and alternatives) to indicate the extent to which one element dominates the other. A scale is used in this pairwise comparison that ultimately allows the calculation of priority weights for each alternative.

A functional hierarchy is used to structure the analysis. At the top of the hierarchy is the overall focus or objective. This focus is broken down into several attributes. The attributes are further broken down into sub-attributes, and so on. The alternatives fall under the last division of the attributes at the bottom of the hierarchy. As an example, Figure 5 shows the hierarchical structure of a national health care plan. At the top of the hierarchy is the focus, National Health Care; at the bottom of the hierarchy are the two alternatives, Plan A and Plan B. In between the focus and the alternatives are one level of attributes and one level of sub-attributes.

The basic AHP procedure requires breaking down the problem according to the hierarchy and making pairwise comparisons between all elements on given level with respect to the element on the level immediately above. The degree of preference that the decision maker has for one element over another is quantified on a scale of one to nine. A "one" is assigned if the elements are preferred equally; a "nine" is assigned if one element is absolutely preferred over the other. The remainder of the values fill in the degrees of preference in between. A matrix of comparisons is constructed that shows the preference of all elements compared to one another under a common element on the next higher level. For example, referring to Figure 5, the preference of "Doctor Choice" versus "Facility Choice" would form a 2x2 matrix since they fall under the common element "Care Choice".

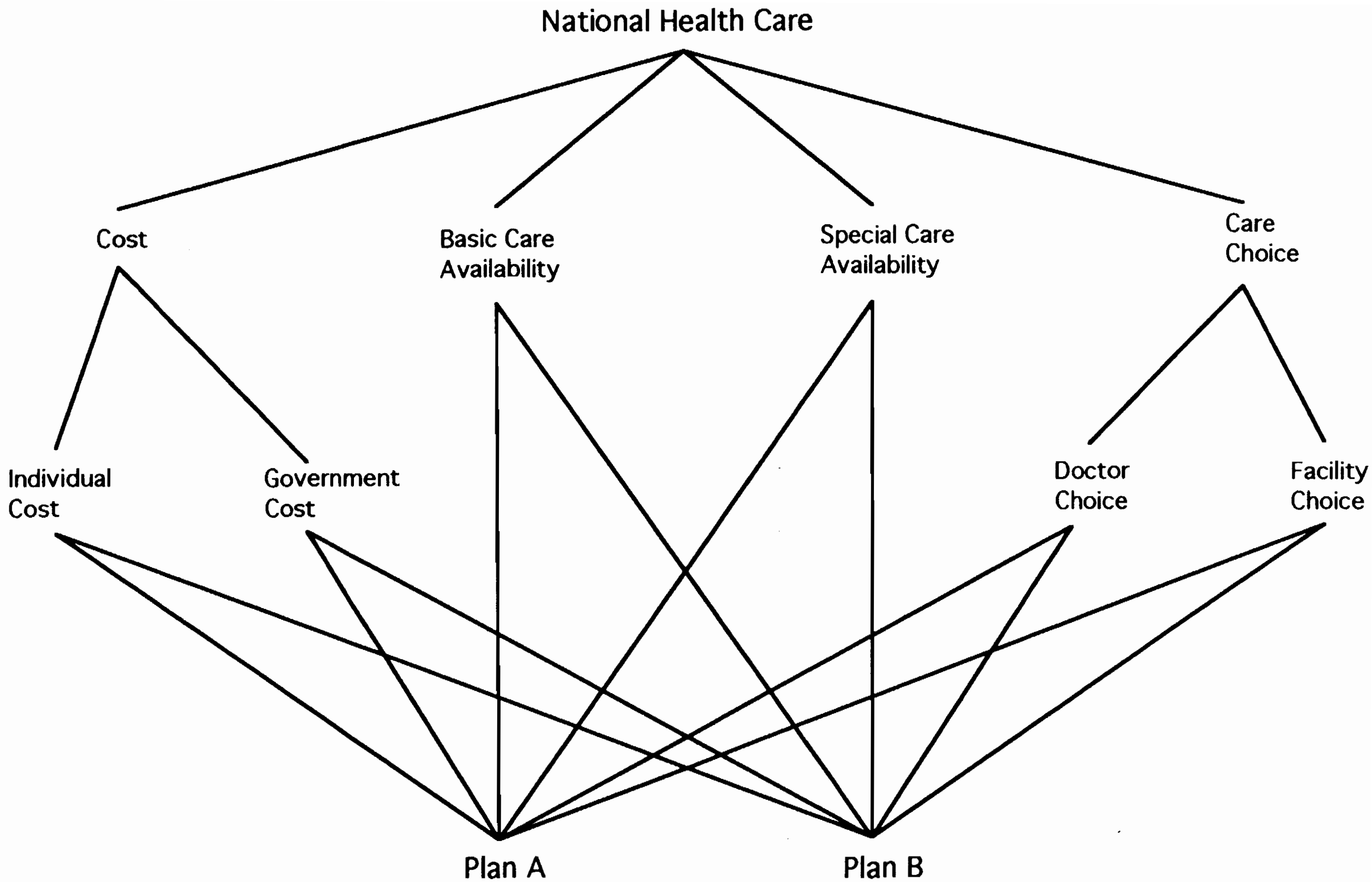

Figure 5. National Health Care heirarchy.

The remainder of the AHP methodology involves the compilation of (1) priority weights for the various attributes, (2) priority weights for alternatives with respect to attributes, and (3) priority weights for alternatives. The alternative with the highest priority weight is the most preferred. As a check to ensure that the individual preferences are assigned in a consistent manner, a mathematical indicator called a consistency ratio may be calculated.

The AHP method of multiattribute decision analysis is very computationally intensive. Fortunately a computer application named Automan is available to perform most of the computational work.[14] Automan is a very powerful tool that queries the analyst for the structure of the hierarchy. Then, Automan requests the pairwise preferences at each level of the hierarchy. Finally, Automan calculates all priority weights, calculates consistency ratios for each matrix, and outputs the final result (of which alternative is most preferable) in the form of a bar graph. Automan even has an option available to perform sensitivity analyses. An example Automan solution to the health care problem of Figure 5 is listed in the Appendix.

5.4.3.4 Life-Cycle Cost Analysis

Life-cycle cost (LCC) analysis is a systems engineering tool that is very important in the design of a system for economic feasibility. Experience shows that the system design decisions that are made early in the life of a project have a tremendous impact on the amount of funding required for the operations and maintenance of the project throughout its lifetime. System LCC methods should be built into the federal budget system to ensure that systems are designed for economy throughout their projected life spans.

Interest in total system cost is increasing, particularly within the DOD where the federal budget crisis is likely to hit the hardest. A rising trend in acquisition, operation, and maintenance costs must be countered at a time when federal budget dollars are becoming more scarce. This alarming growth in costs is due to a number of factors including:

- Engineering changes throughout the design and development of systems
- Changing suppliers in the procurement of system components
- Changes in system production or construction
- Changes in the system logistic support capability
- Initial estimate inaccuracies and changes in estimating procedures.[15]

These factors must be brought under control in all branches of the government. The enforcement of LCC principles is an important step in this regard.

Life-cycle cost refers to all costs incurred over the defined life-cycle of a system or product, and generally includes:

- Research and development cost
- Production and construction cost
- Operation and support cost
- Retirement and disposal cost.

A system LCC analysis is a process of evaluating various alternative courses of action with the objective of choosing the best way to employ scarce resources.

As previously stated, a major portion of the LCC of a system is committed during early systems planning. These early decisions pertain to such issues as operational and maintenance requirements, performance and effectiveness factors, system configuration, production quantities, and logistic support policies. Therefore, if life-cycle cost optimization is a goal, a great deal of attention must be paid to cost emphasis in the early portion of the systems life-cycle. It is important to set goals or cost targets early in system design, and then allocate these targets to subsystems or elements.

During the conceptual design phase, the system LCC may be established as a firm design parameter, with a design-to-cost (DTC) program implemented to ensure that this requirement is closely tracked. In the preliminary design phase, various trade-off studies and alternative system configurations are considered. Life-cycle cost analyses must be conducted as each alternative is evaluated to ensure that each alternative is compatible with the overall system cost target and to determine which alternative is most preferable from the LCC standpoint.

As the system design is refined during the detail design phase and more accurate cost and design data become available, the results are compared with the goals set during the conceptual design phase. Corrective action is taken where necessary. Once the system enters the production phase, the LCC effort primarily involves the collection and analysis of data to determine if the DTC effort was successful.

5.4.3.4.1 Cost Breakdown Structure

The cost breakdown structure (CBS) is an important tool for the systems engineer in the pursuit of LCC analysis. A CBS provides a framework for initial cost allocation, cost categorization, and cost monitoring and control. A CBS is used as a basis for assessing LCC, as it subdivides total cost by major functional activity, major element of the system, or classes of common or like items. It provides management with an organized manner of tracking system cost versus goals. A useful cost breakdown structure should display the following characteristics:

- All life-cycle costs should be considered and identified.
- Cost categories must be well defined and unambiguous.
- Costs must be broken down to allow managers adequate visibility into the system.
- The cost breakdown structure should be subdivided in a manner to allow specific areas of analysis.
- The cost breakdown structure should be coded in a manner to allow the separation of producer, supplier, and consumer costs.
- The cost breakdown structure should be fully compatible with other program documentation.[16]

5.4.3.4.2 Cost Models and Data

Following the establishment of LCC goals, DTC targets, and CBS organization, some type of model is necessary to enable the evaluation of the

LCC process. This model may be a simple set of cost equations or a complex computer program, depending on the design phase and the complexity of the system. For instance, one type of model called a parametric model bases the cost estimate on one or more system parameters. As better design information on these parameters becomes available, the model becomes more accurate.

Once a cost model is chosen, data are gathered for use in the model. Potential sources of data include:

- Existing data libraries
- Advanced planning data
- Cost estimates and predictions
- Supplier documentation
- Engineering test and field data.

Once adequate data are obtained, the model may be used to make the required cost projections.[17]

5.4.3.4.3 Life-Cycle Cost Profile

The information gained from the cost model is ultimately used to profile the cost over the system life cycle. First, all cost generating activities are identified and mapped to the CBS. Individual costs in constant dollars are established for each activity in the CBS. Constant dollars are used so that inflation and other economic effects can be integrated later and updated as they change Then, individual cost elements are projected into the future in a year-by-year fashion. Next, inflationary factors, changing interest rates, and other economic effects are added into the profile. Finally, the individual cost streams by CBS category are summarized to develop a high-level, cost profile. Thus, the system cost over the entire life cycle is reasonably well-known.

The life-cycle cost profile could prove to be indispensable to the budgetary decision maker who is trying to decide whether to vote for or against the appropriation of funds for a particular project. An interesting approach would be to *require* a detailed, substantiated, LCC profile for each project that costs more than *X* dollars before funds are appropriated. Additionally, government agencies could be held to their LCC estimates adjusted for inflation, interest rate fluctuations, and other unforeseen perturbations. A policy such as this would require a good faith estimate, not just a "low-ball" guess to get the program off the ground.

5.4.3.5 Benefit-Cost Analysis

Through the budget process, the federal government determines the allocation of public expenditure. Since such a great deal of national resources is committed to public expenditure, these allocation decisions have great importance in social, political, and economic terms. Typically, the demand for public funds far outstrips the supply of revenues. Therefore, the efficient allocation of funds is vitally important to this process to ensure that as many worthwhile endeavors as possible receive necessary funding. The prevention of allocation of funds to projects that are not worthwhile is also critically important.

Benefit-cost analyses can aid in the efficient allocation of resources to worthy projects and programs. The benefit-cost ratio (B/C) is defined as the ratio of the equivalent worth of benefits to the equivalent worth of costs. The B/C method is commonly used to measure the economic effectiveness of some investment or expenditure that will benefit some segment of the public. In this context, an alternate definition is the ratio of present or annual worth of a benefit to the user public to the present or annual worth of the total costs of supplying that benefit.[18]

Two common formulas for the B/C ratio are (1) the conventional B/C, which is given by

$$B/C = \frac{B}{CR+(O+M)}, \tag{4}$$

and (2) the modified B/C, which is given by

$$B/C = \frac{B-(O+M)}{CR}, \tag{5}$$

where B is the annual worth of benefits to the user, CR is the capital recovery cost, O is the equivalent uniform annual operating cost, and M is the equivalent uniform annual maintenance cost. The modified B/C ratio is currently more commonly used.

A single, independent, investment opportunity is deemed worthwhile if its B/C is greater than or equal to one. In order to evaluate mutually exclusive investment opportunities, an incremental B/C approach is required. To perform an incremental B/C, the alternatives are ranked according to increasing investment. A basic B/C analysis is performed starting with the smallest investment. Once an investment with a B/C greater than or equal to one is encountered, the incremental analysis is used. In an incremental analysis, the ratio is formed using the *differences* between the benefits and costs of the two investments rather than the actual benefits and costs themselves. In this manner, each additional increment of investment must be justified by a corresponding increment of benefit. Thus, the highest investment that has an incremental B/C greater than or equal to one is chosen.

One concern about using B/C methods to justify public expenditure is the possibility that a policy maker could make an arbitrary decision such as, "all projects will a B/C ratio greater than 1.1 are authorized." Such a decision may make perfect sense on the surface, even though there is a highly-desirable, large project with a B/C of 1.09. This type of decision obscures the distinction between independent alternative and mutual exclusivity. The important point is that the only valid arbitrary cut-off point is 1.0.

One of the greatest difficulties in using the benefit-cost analysis to justify a public expenditure is the quantification of the benefit. In many instances, the assignment of a dollar amount to a benefit is almost arbitrary. For example, consider a project that drastically improves the condition and service of a national park. How is such a benefit quantified? In cases such as this, some other approach is warranted. It certainly is not fair to compare a project such as this to one in which the benefit is clearly tangible and quantifiable. Perhaps all such projects should be collected in a category by themselves and evaluated using some other method such as multiattribute decision analysis.

5.4.4 Fiscal Policy

The objective of the application of engineering tools and methods to the budget process is to help decision makers gain a better control of fiscal policy. Fiscal policy is the attempt to control the actions of individuals and businesses by means of spending and taxation. The federal government can spend money in ways to stimulate other activities. It can also institute taxation policies that effect work, investment, consumption, and production decisions. The overall effect of fiscal policy is determined by the relative balance between expenditures (in-flows to the economy) and taxes, charges, and borrowing (out-flows from the economy). A microeconomic effect also exists, which is determined by the effects of the individual programs and policies.

The U.S. government has tried a counter cyclical fiscal policy with dubious results at best. The objective of a counter cyclical fiscal policy is to spend the nation out of a world recession. One of the reasons for the disappointing results of the policy is the time lag between the identification of a problem and the actual implementation of a policy to eliminate the problem. The consequences of this time lag are situations in which a fiscal boost coincides with the next global boom while fiscal contraction coincides with a recession. Two recent examples of this timing problem are:

1. President Bush and the Congress raised taxes at the onset of a global recession.
2. President Clinton has proposed an expansionary economic stimulus package just as economic indicators are pointing to the end of the nation's recession.

Thus, fiscal policies that are intended to be counter cyclical may actually end up compounding the original problem.

Because of the number and complicated interrelationships of variables, the definition of a neutral fiscal policy is very difficult. Inflation, changing unemployment rates, changing exchange rates, and changing population demographics all compound fiscal policy. A simple budget balance may not really be neutral fiscal policy once all variables are taken into account.

The U.S. Council of Economic Advisors typically attempts to adjust the measure of surplus or deficit in relation to deviations from full employment. For example, in periods of high unemployment, the situation warrants the existence of a deficit to cover the increased benefits payouts that would not exist during full employment. Thus, while a budget deficit may exist, the overall character of the policy may be contractionary when viewed from the standpoint of full employment.

While the previously discussed engineering tools can help policy makers *control* fiscal policy and help to ensure that the nation's resources are used wisely, they do not necessarily help policy makers *formulate* fiscal policy. A systems engineering tool does exist that can help to formulate fiscal and monetary policy. This tool is called system dynamics. Before delving into systems dynamics, a discussion of the nation's monetary policy is required.

5.5 The Nation's Money

Although much of the media and political focus is currently on the budget and fiscal policy, the government's control of monetary policy also has a tremendous impact on the economy. By managing its debt portfolio, the government can affect interest rates, and by controlling the amount of new money injected into the economy, it can affect the amount of cash in circulation. Perhaps one of the reasons so much less attention is given to monetary policy is because it is so much more mysterious. Additionally, monetary policy is not controlled by our elected officials; it is set by appointed officials.

Most Americans think of money as the cash in their wallets, what they receive for the work that they do. According to Thoren and Warner:

> "Anything universally acceptable in payment of taxes and debt is money. Money functions as a medium of exchange, a unit of account, and store of value."[19]

The control of the supply of money is a powerful tool of the federal government.

5.5.1 The Federal Reserve System

The Federal Reserve System (FRS) is responsible for formulating and executing the monetary policy of the United States. The FRS is composed of three main bodies:

1. The Board of Governors
2. The twelve Regional Federal Reserve Banks
3. Commercial banks.

The Board of Governors is an agency of the federal government. It consists of 7 members who serve 14-year terms. Each member of the Board of Governors is appointed by the President and confirmed by the Senate. The Regional Federal Reserve Banks are actually private institutions. These banks are *not* government agencies. There are thousands of commercial banks that are members of one of the Regional Federal Reserve Banks. Each member bank holds special, non-marketable stock in its corresponding Regional Federal Reserve Bank.[20]

5.5.2 Monetary Policy

Monetary policy can be simply defined as the guidelines that control the quantity and quality of the money that is supplied to the nation's economy. Monetary policy has become a popular tool for inflation control. It can also be used to stimulate private investment and household spending by reducing interest rates and raising the supply of credit and money. For example, over the past year, the Federal Reserve has steadily lowered interest rates in an attempt to stimulate the economy. As a result, home mortgage interest rates are the lowest they have been in decades. In some areas of the country, the housing market has begun a recovery from the recession of the last several years.

The Federal Reserve has several tools at its disposal in the pursuit of monetary policy, namely:

- Open market operations
- Discount rate control
- Cash reserve requirements.

The Federal Reserve closely monitors and coordinates the use of these tools to create a coherent monetary policy.

5.5.2.1 Open Market Operations

Open market operations refers to the purchase of government securities from the private sector by the Federal Reserve. As the Federal Reserve buys more securities, interest rates are lowered by the bidding-up of bond prices. This begins an interesting chain of causality. The sellers of the government securities receive cash, at least some of which they deposit in banks. This action raises the banks' cash reserves, which allows them to extend greater credit to private borrowers. Private sector interest rates drop and credit terms become easier as the supply of credit is increased. In response, businesses and individuals increase investments, and households increase spending on consumer goods. All of this is the result of the Federal Reserve's decision to buy more government securities (such as Treasury bills and bonds). The clear understanding of open market operations certainly requires that one takes a systems view of monetary policy.[21]

5.5.2.2 Control of the Discount Rate

This sub-policy is often used by the Federal Reserve in conjunction with open market operations. The discount rate is the interest rate at which commercial banks can borrow from the Federal Reserve. If the Federal Reserve lowers the discount rate, commercial banks are able to extend better credit terms to private borrowers.

5.5.2.3 Cash Reserve Requirements

The Federal Reserve's cash reserve policy requires that a member bank must maintain deposits at the Regional Federal Reserve Bank at a certain proportion to its liabilities. Banks cannot expand their earning assets beyond the maximum allowed by the reserve requirement. If the Federal Reserve reduces the reserve requirement, banks can expand their loan portfolio, which increases the volume of credit outstanding and the amount of money in circulation.

5.5.2.4 Coordinated Monetary Policy

All of the examples cited under monetary policy, open market operations, discount rate control, and cash reserve requirements are expansionary in nature. The action of the Federal Reserve could be reversed in each of these cases, which would result in a contractionary monetary policy.

The federal government can coordinate monetary and fiscal policy to form a national economic policy. A major goal of such a policy is the stabilization of the economy, which is a worthy, but very complex task.

5.6 Economic Stabilization

The stabilization of the economy is a major goal of the federal government in its execution of fiscal and monetary policies. Economic stabilization is represented by full employment, control of inflation, and an equitable balance of payments. Several issues make the coordination of fiscal and monetary policies in the name of economic stabilization a difficult goal to reach.

Perhaps the greatest difficulty in implementing a coordinated economic policy is the problem of time lags. Three types of time lag exist:

1. Recognition lag
2. Decision lag
3. Effect lag.

Recognition lag is the period between the initial manifestation of an economic problem and the recognition by government authorities that a change in economic policy is needed. Decision lag is the time between when a need for action is recognized and the action is actually taken. Decision lag is usually significantly shorter for monetary policy than fiscal policy. This is understandable since the Federal Reserve Board of Governors consists of only seven people, while the formulators of fiscal policy probably number in the thousands. Effect lag is the period between when the action is taken and the effect is realized.

Some economists believe that the total time lag is so great and filled with such uncertainty that the best policy is one of inaction. These economists fear that by the time the effect is realized, the economic situation may be radically different from when the problem was recognized. Other economists have pursued sophisticated forecasting techniques or computerized economic models to try to reduce recognition lag. Many economic models of the United States exist, but little progress has been made in successfully applying the models except in the most basic forecasting applications.[22] System dynamics is a powerful modeling technique that can aid in the solution to this problem.

5.7 System Dynamics and the Debt Money System

In the 1960s, the government's economic philosophy consisted of measuring the potential capacity of the economy and then stimulating the economy to reach that capacity through fiscal and monetary policies. The government economists believed that four percent was a normal unemployment rate, and they forecasted the potential gross national product (GNP) based on that rate. When the actual GNP was forecasted to be less than the potential GNP, the economists believed that the government could increase spending and/or cut taxes without the danger of increasing inflation. This was a popular and appealing philosophy because it enabled the government to easily justify spending increases. The goal of balancing the federal budget was hereby abandoned. The new goal was the expansion of the economy through the use of coordinated fiscal and monetary policies.[23]

This economic philosophy began to encounter difficulties as the "system" began to expect spending increases. The nation's economy was addicted to expansionary economic policy. The policy makers could not adopt more neutral policies without the risk of a tremendous unemployment problem. Consequently, inflation began to rise. In the early 1970s, the government experimented with selected price controls as a means to combat the growing inflation problem. Price controls allowed the policy makers to artificially hold down inflation while they battled unemployment. However, the economy began to experience serious distortions because of the selective controls, and the administration was forced to abandon price controls altogether. After price controls were lifted, the United

States experienced the worst inflation rates since World War II.[24] The nation was feeling the pain of the debt money system.

5.7.1 The Debt Money System

The "debt money system" is a term that may be applied to the U.S. monetary system because almost all new money is loaned into circulation as a debt. Money is borrowed into existence, and all of this money, plus interest, must eventually be paid back to the banks that created it. However, as banks create money to loan, they only create the principal. The interest due on the debt must come out of the existing money supply. Here lies a serious problem. As more and more money is loaned into existence, the total debt to the banks rises. As the debt level increases, the amount of interest due on that debt increases. Since the interest must come from the existing money supply, the rising interest payments cause a reduction in that supply. The contraction of the money supply necessitates more borrowing, and the cycle begins anew.[25]

A brief overview of the money-creation process is necessary to fully understand the debt money system. This money-creation process can be summarized in seven steps:[26]

1. The Congress must authorize a higher federal debt so that the previous level can be legally exceeded.
2. The Treasury writes interest-bearing bonds for the amount of funds needed, and it sells these bonds to the FRS.
3. The Federal Reserve creates the money to buy the bonds.

4. The Treasury writes checks against the loan to pay its obligations.

5. These checks are deposited in commercial banks by the people who receive them.

6. The checks are cleared through a computerized system, and the Treasury's account is debited and the recipients' accounts are credited, which increases the commercial banks' reserves.

7. This new reserve money is used by the commercial banks to create new deposit credit money to lend to their customers.

The FRS can also remove reserves from the money system by selling bonds from its portfolio to the banks. The check the FRS receives in payment for the bonds is written on a commercial bank's reserve account. The FRS takes the check and simply erases the reserves by canceling them out of existence. As reserves are removed from the banking system, a contractionary trend develops. The reserves form the basis of the commercial banks' loan portfolio; when the reserves are reduced, a portion of the loans must be called or not renewed.[27]

5.7.1.1 The Debt Money System and Inflation

In a debt money system, inflation may be termed debt-induced monetary devaluation. It is characterized by the loss of the purchasing power of the nation's currency. The progressive devaluation of the dollar, which is a result of the inherent design flaw in the debt money system, causes steadily rising prices. This design flaw is the creation of new money as a debt.

When new money is created as debt, the system is trapped in a cycle of increased borrowing in an attempt to pay the principal and interest of previous debts. These interest charges on previous debts represent money that was never created in the first place. When this debt was created by loaning new money into existence, only the principal was actually monetized. This type of monetary system is inherently inflationary due to the shortage of money available to pay off unmonetized debt. The money shortage causes continually increasing borrowing. Businesses must charge higher prices for their goods and services in order to cover the increased cost of business borrowing.

The devaluation of the dollar leads to a real and valid demand for a growth in the supply of money. More and more money is borrowed by individuals and by businesses to meet the growing need for funds, but the increased borrowing can never keep pace with the compounding debt that initiated the cycle in the first place. Thus, there is a very real trend of a growing money supply during inflationary times; however, this growth in the money supply is a symptom, not a cause, of inflation.[28]

5.7.1.2 Debt, Interest, and Usury

Every product or service that is for sale carries with it some interest charge that eventually makes its way back to a financial institution. This interest burden is growing rapidly, and it adds to the cost of producing goods and providing services. This effect is a particular hindrance in an increasingly competitive global market place. Additionally, when interest rates rise, the debt load increases even faster.

A related problem occurs when a business or individual borrows more money to pay interest on a debt. In this case, the borrowed money never leaves the bank; it never becomes part of the money supply. The bank simply makes bookkeeping entries to handle the transaction. Borrowing to pay interest does not increase the money supply; it only increases the total amount of debt in the economy. The company's debt is increased, and the prices of goods and services are increased, but there is no new money in the economy to handle the higher prices and pay off the interest on the increased debt.[29]

Borrowing to pay debt increases what is known as usury. Usury makes up the difference between the money supply and the total debt, and it may be defined as:

> "...any charge at all by a private lender for the use of money the lender is allowed to create out of nothing as a debt to the borrower and an interest-earning asset to the lender."[30]

The exponential growth of usury in debt money system is inevitable.

5.7.1.3 The Instability of a Debt Money System

A debt money system is inherently unstable. Debt by its very nature is subject to exponential growth according to

$$D = P(1+r)^{n}, \qquad (6)$$

where D represents total debt, P is the debt principal, r is the interest rate per compounding period, and n is the number of compounding periods.

In summary, a debt money system is problematic because::

1. Most money is created as loans, and it is therefore a debt that must be repaid.
2. Only the principal enters the money supply when a bank loan is made.
3. The payment of usury removes money from circulation and makes the total debt unpayable.
4. The removal of money from circulation causes a shortage that triggers additional borrowing to maintain an adequate money supply.
5. This additional borrowing increases the debt and the usury in an exponential fashion.
6. The rate of debt expansion always exceeds the rate of money expansion, which causes the debt-to-money ratio to expand exponentially, leading to a chronic shortage of money.

The implications of the long term use of a debt money system can be more easily explored and understood through the use of system dynamics, the topic of the next section.

5.7.2 System Dynamics

System dynamics is a very powerful methodology for gaining insight into complex problem, issues, and systems. Whereas the previously covered systems engineering tools and methods can help the policy maker control and implement fiscal and monetary policy, system dynamics can help the policy maker to formulate, evaluate, and modify fiscal and monetary policy. System dynamics is primarily concerned with complex, dynamic S-T-E-P systems and how system structure and decision making policies affect the behavior of systems.[31] Fiscal and monetary policy issues certainly meet the complex, dynamic, and S-T-E-P criteria.

System dynamics is a modeling technique that is based on the premise that all systems that change with time may be represented by interrelated, varying levels and rates. Levels represent an accumulation within a system, while rates represent flows from one area to another of what has been accumulated. Changes in levels are caused and controlled by rates.

5.7.2.1. The System Dynamics Procedure

The system dynamics methodology consists of three basic steps:

1. The creation of a mental model in the form of a verbal description,
2. The expression of the verbal description in the form of a flow diagram, and
3. The conversion of the flow diagram to a set of simultaneous difference equations.

Typically, a computer is used to solve the difference equations. Thus, the system dynamics approach uses three alternative forms of modeling in its procedure.[32]

The verbal description is simply a mental model of the system that is expressed in words. This mental model is used to help construct the visual model, known as the causal diagram.

5.7.2.1.1 The Causal Diagram

One of the key points of system dynamics is that the dynamic tendencies of any system are rooted in its causal structure. The construction of a causal diagram helps to illuminate the causal structure of the system. The causal diagram also assists in the formulation of difference equations.

The first step in the construction of a causal diagram is the identification of the key variables of the system that need to be modeled. The key variables may be derived from a verbal description of the problem.

The second step in causal diagram development is to indicate cause-effect relationships between pairs of variables by using arrows The arrows point from variables that cause an effect, or independent variables, to variables that are effected, or dependent variables.

The third step in building a causal diagram is the indication of the polarity of the relationship between the two variables joined by arrows. A plus sign indicates that the dependent variable changes in the same direction as changes in the independent variable. A minus sign indicates that the dependent variable changes in the opposite direction as changes in the independent variable.

The classification of system variables is the final step in causal diagram construction. System variables are classified as level variables, rate variables, auxiliary variables, or constants. Level variables represent the accumulation of resources or the state of the system at a given point in time. Rate variables represent flows, and they cause changes in level variables. The causal relationship between a rate and a level is an actual physical flow of some type; the causal relationship between a level and a rate is one of an information flow rather than a physical flow. Auxiliary variables are all variables other than levels and rates that appear in a path from a level to a rate. A constant is not a variable, but a parameter that has an arrow pointing from it to a variable.

To facilitate the easy identification of the different variable types on a causal diagram, solid arrows are used to connect rates *to* levels, and they represent real physical flows. Dashed arrows are used to represent information flows, and so they connect levels *to* rates. Dashed lines also represent information flows to and from auxiliary variables and from constants.[33]

5.7.2.1.2 Feedback Loops

Feedback loops and their effects are an extremely important part of system dynamics. Feedback loops are created when two or more causal relationships close on themselves. Within a feedback loop, the change in a variable cascades through all of the variables that make up the loop until the variable that initially changed becomes affected itself. A feedback loop is classified as either positive or negative. The classification of the feedback loop may be determined by counting the number of negative polarities around the path of the loop. An even number of negative polarities represents a positive feedback loop. A positive feedback loop is characterized as reinforcing variable changes in the same direction as the change, which leads to sustained growth or decline. An odd number of negative polarities is indicative of a negative feedback loop. A negative feedback loop is characterized as resisting or countering variable change, which results in fluctuation or the maintenance of equilibrium.

A feedback system is one or more connected feedback loops. The order of a feedback system is determined by the maximum number of level variables in any of the system's loops. Once causal diagrams, the classification of variables, and the structure of feedback loops are understood, the system dynamics mathematical model may be formulated.

5.7.2.1.3 System Dynamics Equations

System dynamics equations represent the mathematical model of the system. Level equations, rate equations, and auxiliary equations are used to quantify the accumulations, flows, and interrelationships that are revealed in the causal diagram modeling process.

A level variable, L, represents the accumulation of some quantity in the system at time t. The rate variable, R, represents the change in the level variable over the time interval from $t-1$ to t. The mathematical relationship between the level and rate variables is given by the difference equation

$$L.K = L.J + (DT)(R.JK), \tag{7}$$

where DT represents the time interval between $t-1$ and t. System dynamics uses difference equations and postscript notation because a convenient system dynamics computer program called DYNAMO has been developed, and computers cannot easily handle integral and subscript notation. In the system dynamics postscript notation, *.K* stands for present time, *.J* stands for past time, *.L* stands for future time, and *DT* represents the solution interval. Since rate variables are assumed constant over the solution interval, *DT*, a double postscript notation is used with *.JK* as the postscript on the right side of the difference equation and *.KL* as the postscript on the left side.[34] A set of system dynamic equations representing a given problem may be solved analytically, numerically, or with the aid of a computer.

Now that the basics of system dynamics are covered, the method may be applied to the debt money system.

5.7.2.2 System Dynamics Applied to the Debt Money System

The debt money system is currently in use in the United States today. The use of system dynamics methods allows the analyst to peer into the future to evaluate the long-term performance of this system. The system dynamics model of such a complex system may contain up to hundreds of variables. For the purpose of this analysis and the demonstration of the method's applicability, a simplified model of this complicated system is chosen.[35] The objective here is not to predict the future economy with certainty, but rather, it is to demonstrate that system dynamics techniques can be used to help understand economic policy.

The basic approach to the system dynamics analysis of this model is to develop an accurate causal diagram of the system, reflect the results of the causal diagram in the system dynamics equations, and then solve the equations to determine the performance of the system. Then, policy variables or system parameters may be varied to determine the sensitivity of the system to various changes in the system.

The causal diagram of this system is shown in Figure 6. The system contains two level variables, debt, *D,* and capital, *C.* The key to the abbreviations is given in Table 3.

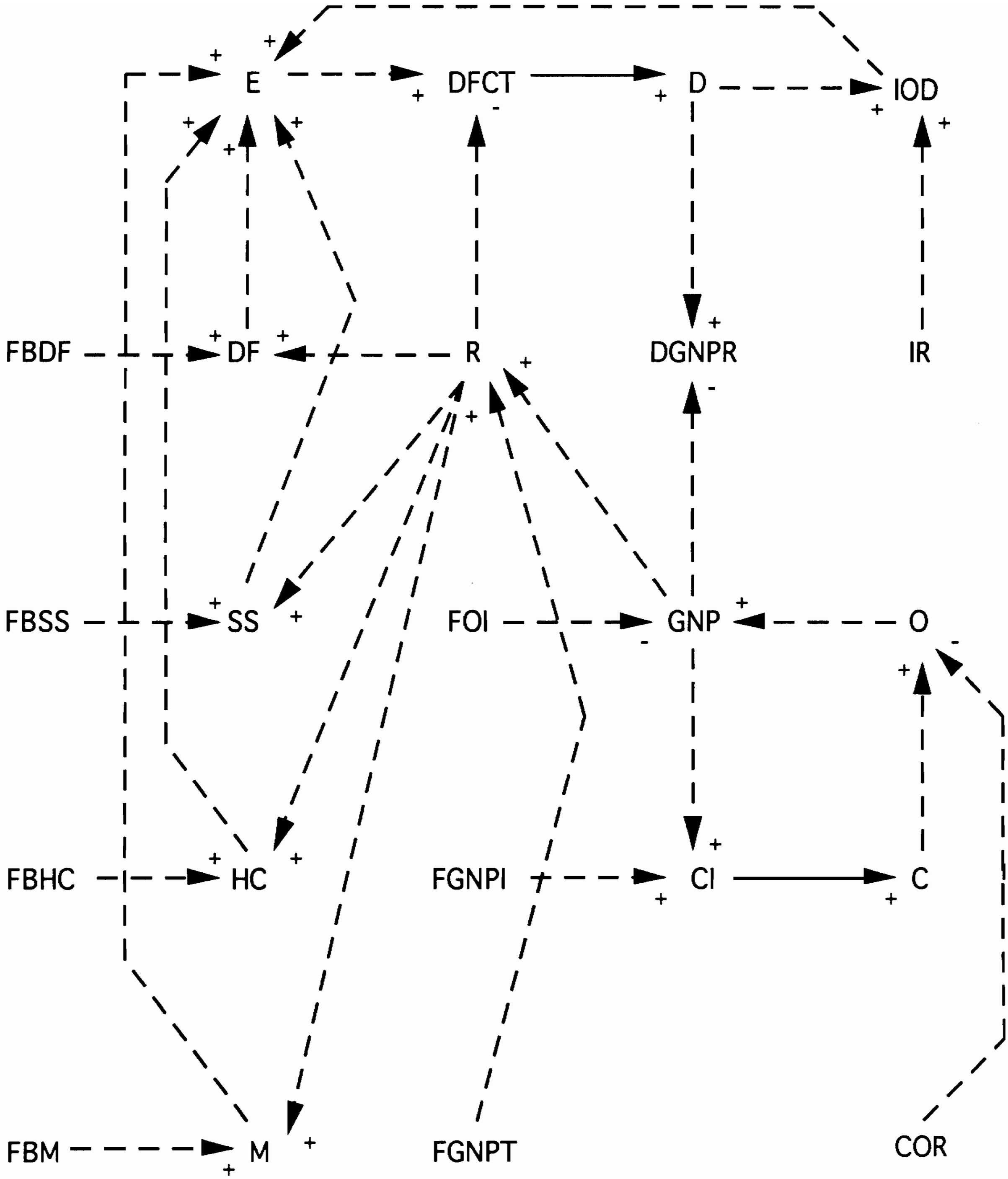

Figure 6. Causal diagram of the debt money system.

The next step in the analysis of the debt money system is the formulation of system dynamics equations to correspond to the causal diagram. The system dynamics equations, along with the key to abbreviations, are given in Table 3. Now the equations must be evaluated. Unfortunately, this model does not yield a "clean" analytical solution. Therefore, a spreadsheet program is used to solve the equations numerically. The use of a spreadsheet facilitates the alteration of the model according to some policy or parameter change. The spreadsheet instantaneously updates all variables that are affected by the change.

The spreadsheet for the first run of the model, called Policy A, is shown in Table 4. In this model, the growth of GNP is able to outpace the growth of the debt, which leads to a steadily declining debt-to-GNP ratio, as shown in Figure 7. However, the debt is still growing at a tremendous pace, as shown in the lower curve of Figure 8. If the economy falters during this fifty year span, the consequences could be disastrous because the ability to pay down the growing debt would be seriously hampered. Additionally, a faltering economy may cause the debt to grow even faster than its depiction in this model due to the increased entitlements that would logically be required. The important information to take from this model is not the values themselves, but the trends of the variables over time. More useful information is obtained by changing some of the constants and evaluating the model again.

Table 3. System dynamics equations for debt money model.

SYSTEM DYNAMICS EQ.	KEY
C.K=C.J+(DT)(CI.JK)	C - CAPITAL ($)
C=CN	
CN=5.0E12	CN - CAPITAL INITIAL VALUE ($)
CI.KL=GNP.K*FGNPI	CI - CAPITAL INVESTMENT ($/YR)
FGNPI=0.2	FGNPI - FRACTION GNP INVESTED (DIM)
GNP.K=O.K*(1-FOI)	GNP - GROSS NATIONAL PRODUCT ($/YR)
FOI=0.4	FOI - FRACT OUTPUTS TO INPUTS (DIM)
O.K=C.K/COR	O - OUTPUT ($/YR)
COR=1.2	COR - CAPITAL OUTPUT RATIO (YR)
D.K=D.J+(DT)(DFCT.JK)	D- DEBT ($)
D=DN	
DN=2.OE12	DN - DEBT INITIAL VALUE
DFCT.KL=E.K-R.K	DFCT - DEFICIT ($/YR)
R.K=GNP.K*FGNPT	R - REVENUES ($/YR)
FGNPT=0.2	FGNPT - FRACTION GNP TO TAXES (DIM)
E.K=DF.K+SS.K+HC.K+M.K+IOD.K	E - EXPENDITURES ($/YR)
DF.K=R.K*FBDF	DF - DEFENSE ($/YR)
FBDF=0.20	FBDF - FRACT BUDGET TO DEF (DIM)
SS.K=R.K*FBSS	SS - SOCIAL SECURITY ($/YR)
FBSS=0.25	FBSS - FRACT BUDGET TO SS (DIM)
HC.K=R.K*FBHC	HC - HEALTH CARE ($/YR)
FBHC=0.20	FBHC - FRACT BUDGET TO HC (DIM)
M.K=R.K*FBM	M - MISCELLANEOUS ($/YR)
FBM=0.35	FBM - FRACT BUDGET TO MISC (DIM)
IOD.K=D.K*IR	IOD - INTEREST ON DEBT ($/YR)
IR=0.075	IR - INTEREST RATE (FRACT/YR)
DGNPR.K=D.K/GNP.K	DGNPR - DEBT-TO-GNP RATIO (YR)

Table 4. Debt money system Policy A.

Year	Capital ($)	CapInv ($/Yr)	GNP ($/Yr)	Output ($/Yr)	Debt ($)	Deficit ($/Yr)	Exp ($/Yr)	Rev ($/Yr)	FGNPT	Def ($/Yr)	SocSec ($/Yr)	Health ($/Yr)	Misc ($/Yr)	IOD ($/YR)	Debt/GNP
0	5.0000E+12	5E+11	2.5E+12	4.1667E+12	2.0000E+12	1.5E+11	6.5E+11	5E+11	0.2	1E+11	1.25E+11	1E+11	1.75E+11	1.5E+11	0.8
1	5.5000E+12	5.5E+11	2.75E+12	4.5833E+12	2.1500E+12	1.6125E+11	7.1125E+11	5.5E+11	0.2	1.1E+11	1.375E+11	1.1E+11	1.925E+11	1.6125E+11	0.78181818
2	6.0500E+12	6.05E+11	3.025E+12	5.0417E+12	2.3113E+12	1.7334E+11	7.7834E+11	6.05E+11	0.2	1.21E+11	1.5125E+11	1.21E+11	2.1175E+11	1.7334E+11	0.76404959
3	6.6550E+12	6.655E+11	3.3275E+12	5.5458E+12	2.4846E+12	1.8634E+11	8.5184E+11	6.655E+11	0.2	1.331E+11	1.6638E+11	1.331E+11	2.3293E+11	1.8634E+11	0.74668482
4	7.3205E+12	7.3205E+11	3.6603E+12	6.1004E+12	2.6709E+12	2.0032E+11	9.3237E+11	7.3205E+11	0.2	1.4641E+11	1.8301E+11	1.4641E+11	2.5622E+11	2.0032E+11	0.72971471
5	8.0526E+12	8.0526E+11	4.0263E+12	6.7105E+12	2.8713E+12	2.1534E+11	1.0206E+12	8.0526E+11	0.2	1.6105E+11	2.0131E+11	1.6105E+11	2.8184E+11	2.1534E+11	0.71313029
6	8.8578E+12	8.8578E+11	4.4289E+12	7.3815E+12	3.0866E+12	2.315E+11	1.1173E+12	8.8578E+11	0.2	1.7716E+11	2.2145E+11	1.7716E+11	3.1002E+11	2.315E+11	0.69692278
7	9.7436E+12	9.7436E+11	4.8718E+12	8.1197E+12	3.3181E+12	2.4886E+11	1.2232E+12	9.7436E+11	0.2	1.9487E+11	2.4359E+11	1.9487E+11	3.4103E+11	2.4886E+11	0.68108363
8	1.0718E+13	1.0718E+12	5.359E+12	8.9316E+12	3.5670E+12	2.6752E+11	1.3393E+12	1.0718E+12	0.2	2.1436E+11	2.6795E+11	2.1436E+11	3.7513E+11	2.6752E+11	0.66560445
9	1.1790E+13	1.179E+12	5.8949E+12	9.8248E+12	3.8345E+12	2.8759E+11	1.4666E+12	1.179E+12	0.2	2.3579E+11	2.9474E+11	2.3579E+11	4.1264E+11	2.8759E+11	0.65047708
10	1.2969E+13	1.2969E+12	6.4844E+12	1.0807E+13	4.1221E+12	3.0915E+11	1.606E+12	1.2969E+12	0.2	2.5937E+11	3.2422E+11	2.5937E+11	4.539E+11	3.0915E+11	0.63569351
11	1.4266E+13	1.4266E+12	7.1328E+12	1.1888E+13	4.4312E+12	3.3234E+11	1.7589E+12	1.4266E+12	0.2	2.8531E+11	3.5664E+11	2.8531E+11	4.993E+11	3.3234E+11	0.62124593
12	1.5692E+13	1.5692E+12	7.8461E+12	1.3077E+13	4.7636E+12	3.5727E+11	1.9265E+12	1.5692E+12	0.2	3.1384E+11	3.923E+11	3.1384E+11	5.4922E+11	3.5727E+11	0.6071267
13	1.7261E+13	1.7261E+12	8.6307E+12	1.4384E+13	5.1208E+12	3.8406E+11	2.1102E+12	1.7261E+12	0.2	3.4523E+11	4.3153E+11	3.4523E+11	6.0415E+11	3.8406E+11	0.59332837
14	1.8987E+13	1.8987E+12	9.4937E+12	1.5823E+13	5.5049E+12	4.1287E+11	2.3116E+12	1.8987E+12	0.2	3.7975E+11	4.7469E+11	3.7975E+11	6.6456E+11	4.1287E+11	0.57984364
15	2.0886E+13	2.0886E+12	1.0443E+13	1.7405E+13	5.9178E+12	4.4383E+11	2.5325E+12	2.0886E+12	0.2	4.1772E+11	5.2216E+11	4.1772E+11	7.3102E+11	4.4383E+11	0.56666537
16	2.2975E+13	2.2975E+12	1.1487E+13	1.9146E+13	6.3616E+12	4.7712E+11	2.7746E+12	2.2975E+12	0.2	4.595E+11	5.7437E+11	4.595E+11	8.0412E+11	4.7712E+11	0.55378661
17	2.5272E+13	2.5272E+12	1.2636E+13	2.106E+13	6.8387E+12	5.129E+11	3.0401E+12	2.5272E+12	0.2	5.0545E+11	6.3181E+11	5.0545E+11	8.8453E+11	5.129E+11	0.54120055
18	2.7800E+13	2.78E+12	1.39E+13	2.3166E+13	7.3516E+12	5.5137E+11	3.3313E+12	2.78E+12	0.2	5.5599E+11	6.9499E+11	5.5599E+11	9.7299E+11	5.5137E+11	0.52890054
19	3.0580E+13	3.058E+12	1.529E+13	2.5483E+13	7.9030E+12	5.9272E+11	3.6507E+12	3.058E+12	0.2	6.1159E+11	7.6449E+11	6.1159E+11	1.0703E+12	5.9272E+11	0.51688007
20	3.3637E+13	3.3637E+12	1.6819E+13	2.8031E+13	8.4957E+12	6.3718E+11	4.0009E+12	3.3637E+12	0.2	6.7275E+11	8.4094E+11	6.7275E+11	1.1773E+12	6.3718E+11	0.5051328
21	3.7001E+13	3.7001E+12	1.8501E+13	3.0834E+13	9.1329E+12	6.8497E+11	4.3851E+12	3.7001E+12	0.2	7.4002E+11	9.2503E+11	7.4002E+11	1.295E+12	6.8497E+11	0.49365251
22	4.0701E+13	4.0701E+12	2.0351E+13	3.3918E+13	9.8178E+12	7.3634E+11	4.8065E+12	4.0701E+12	0.2	8.1403E+11	1.0175E+12	8.1403E+11	1.4245E+12	7.3634E+11	0.48243313
23	4.4772E+13	4.4772E+12	2.2386E+13	3.731E+13	1.0554E+13	7.9156E+11	5.2687E+12	4.4772E+12	0.2	8.9543E+11	1.1193E+12	8.9543E+11	1.567E+12	7.9156E+11	0.47146874
24	4.9249E+13	4.9249E+12	2.4624E+13	4.1041E+13	1.1346E+13	8.5093E+11	5.7758E+12	4.9249E+12	0.2	9.8497E+11	1.2312E+12	9.8497E+11	1.7237E+12	8.5093E+11	0.46075354
25	5.4174E+13	5.4174E+12	2.7087E+13	4.5145E+13	1.2197E+13	9.1475E+11	6.3321E+12	5.4174E+12	0.2	1.0835E+12	1.3543E+12	1.0835E+12	1.8961E+12	9.1475E+11	0.45028187
26	5.9591E+13	5.9591E+12	2.9795E+13	4.9659E+13	1.3111E+13	9.8336E+11	6.9424E+12	5.9591E+12	0.2	1.1918E+12	1.4898E+12	1.1918E+12	2.0857E+12	9.8336E+11	0.44004819
27	6.5550E+13	6.555E+12	3.2775E+13	5.4625E+13	1.4095E+13	1.0571E+12	7.6121E+12	6.555E+12	0.2	1.311E+12	1.6387E+12	1.311E+12	2.2942E+12	1.0571E+12	0.4300471
28	7.2105E+13	7.2105E+12	3.6052E+13	6.0087E+13	1.5152E+13	1.1364E+12	8.3469E+12	7.2105E+12	0.2	1.4421E+12	1.8026E+12	1.4421E+12	2.5237E+12	1.1364E+12	0.4202733
29	7.9315E+13	7.9315E+12	3.9658E+13	6.6096E+13	1.6288E+13	1.2216E+12	9.1532E+12	7.9315E+12	0.2	1.5863E+12	1.9829E+12	1.5863E+12	2.776E+12	1.2216E+12	0.41072164
30	8.7247E+13	8.7247E+12	4.3624E+13	7.2706E+13	1.7510E+13	1.3132E+12	1.0038E+13	8.7247E+12	0.2	1.7449E+12	2.1812E+12	1.7449E+12	3.0536E+12	1.3132E+12	0.40138705
31	9.5972E+13	9.5972E+12	4.7986E+13	7.9976E+13	1.8823E+13	1.4117E+12	1.1009E+13	9.5972E+12	0.2	1.9194E+12	2.3993E+12	1.9194E+12	3.359E+12	1.4117E+12	0.39226462
32	1.0557E+14	1.0557E+13	5.2784E+13	8.7974E+13	2.0235E+13	1.5176E+12	1.2075E+13	1.0557E+13	0.2	2.1114E+12	2.6392E+12	2.1114E+12	3.6949E+12	1.5176E+12	0.38334951
33	1.1613E+14	1.1613E+13	5.8063E+13	9.6771E+13	2.1753E+13	1.6314E+12	1.3244E+13	1.1613E+13	0.2	2.3225E+12	2.9031E+12	2.3225E+12	4.0644E+12	1.6314E+12	0.37463703
34	1.2774E+14	1.2774E+13	6.3869E+13	1.0645E+14	2.3384E+13	1.7538E+12	1.4528E+13	1.2774E+13	0.2	2.5548E+12	3.1935E+12	2.5548E+12	4.4708E+12	1.7538E+12	0.36612255
35	1.4051E+14	1.4051E+13	7.0256E+13	1.1709E+14	2.5138E+13	1.8853E+12	1.5937E+13	1.4051E+13	0.2	2.8102E+12	3.5128E+12	2.8102E+12	4.9179E+12	1.8853E+12	0.35780158
36	1.5456E+14	1.5456E+13	7.7282E+13	1.288E+14	2.7023E+13	2.0267E+12	1.7483E+13	1.5456E+13	0.2	3.0913E+12	3.8641E+12	3.0913E+12	5.4097E+12	2.0267E+12	0.34966973
37	1.7002E+14	1.7002E+13	8.501E+13	1.4168E+14	2.9050E+13	2.1787E+12	1.9181E+13	1.7002E+13	0.2	3.4004E+12	4.2505E+12	3.4004E+12	5.9507E+12	2.1787E+12	0.34172269
38	1.8702E+14	1.8702E+13	9.3511E+13	1.5585E+14	3.1229E+13	2.3421E+12	2.1044E+13	1.8702E+13	0.2	3.7404E+12	4.6755E+12	3.7404E+12	6.5458E+12	2.3421E+12	0.33395626
39	2.0572E+14	2.0572E+13	1.0286E+14	1.7144E+14	3.3571E+13	2.5178E+12	2.309E+13	2.0572E+13	0.2	4.1145E+12	5.1431E+12	4.1145E+12	7.2003E+12	2.5178E+12	0.32636635
40	2.2630E+14	2.263E+13	1.1315E+14	1.8858E+14	3.6088E+13	2.7066E+12	2.5336E+13	2.263E+13	0.2	4.5259E+12	5.6574E+12	4.5259E+12	7.9204E+12	2.7066E+12	0.31894893
41	2.4893E+14	2.4893E+13	1.2446E+14	2.0744E+14	3.8795E+13	2.9096E+12	2.7802E+13	2.4893E+13	0.2	4.9785E+12	6.2231E+12	4.9785E+12	8.7124E+12	2.9096E+12	0.31170009
42	2.7382E+14	2.7382E+13	1.3691E+14	2.2818E+14	4.1705E+13	3.1279E+12	3.051E+13	2.7382E+13	0.2	5.4764E+12	6.8455E+12	5.4764E+12	9.5836E+12	3.1279E+12	0.304616
43	3.0120E+14	3.012E+13	1.506E+14	2.51E+14	4.4833E+13	3.3624E+12	3.3482E+13	3.012E+13	0.2	6.024E+12	7.53E+12	6.024E+12	1.0542E+13	3.3624E+12	0.29769291
44	3.3132E+14	3.3132E+13	1.6566E+14	2.761E+14	4.8195E+13	3.6146E+12	3.6747E+13	3.3132E+13	0.2	6.6264E+12	8.283E+12	6.6264E+12	1.1596E+13	3.6146E+12	0.29092716
45	3.6445E+14	3.6445E+13	1.8223E+14	3.0371E+14	5.1810E+13	3.8857E+12	4.0331E+13	3.6445E+13	0.2	7.289E+12	9.1113E+12	7.289E+12	1.2756E+13	3.8857E+12	0.28431518
46	4.0090E+14	4.009E+13	2.0045E+14	3.3408E+14	5.5695E+13	4.1772E+12	4.4267E+13	4.009E+13	0.2	8.018E+12	1.0022E+13	8.018E+12	1.4031E+13	4.1772E+12	0.27785347
47	4.4099E+14	4.4099E+13	2.2049E+14	3.6749E+14	5.9873E+13	4.4904E+12	4.8589E+13	4.4099E+13	0.2	8.8197E+12	1.1025E+13	8.8197E+12	1.5435E+13	4.4904E+12	0.27153862
48	4.8509E+14	4.8509E+13	2.4254E+14	4.0424E+14	6.4363E+13	4.8272E+12	5.3336E+13	4.8509E+13	0.2	9.7017E+12	1.2127E+13	9.7017E+12	1.6978E+13	4.8272E+12	0.26536729
49	5.3359E+14	5.3359E+13	2.668E+14	4.4466E+14	6.9190E+13	5.1893E+12	5.8549E+13	5.3359E+13	0.2	1.0672E+13	1.334E+13	1.0672E+13	1.8676E+13	5.1893E+12	0.25933621
50	5.8695E+14	5.8695E+13	2.9348E+14	4.8913E+14	7.4379E+13	5.5785E+12	6.4274E+13	5.8695E+13	0.2	1.1739E+13	1.4674E+13	1.1739E+13	2.0543E+13	5.5785E+12	0.25344221

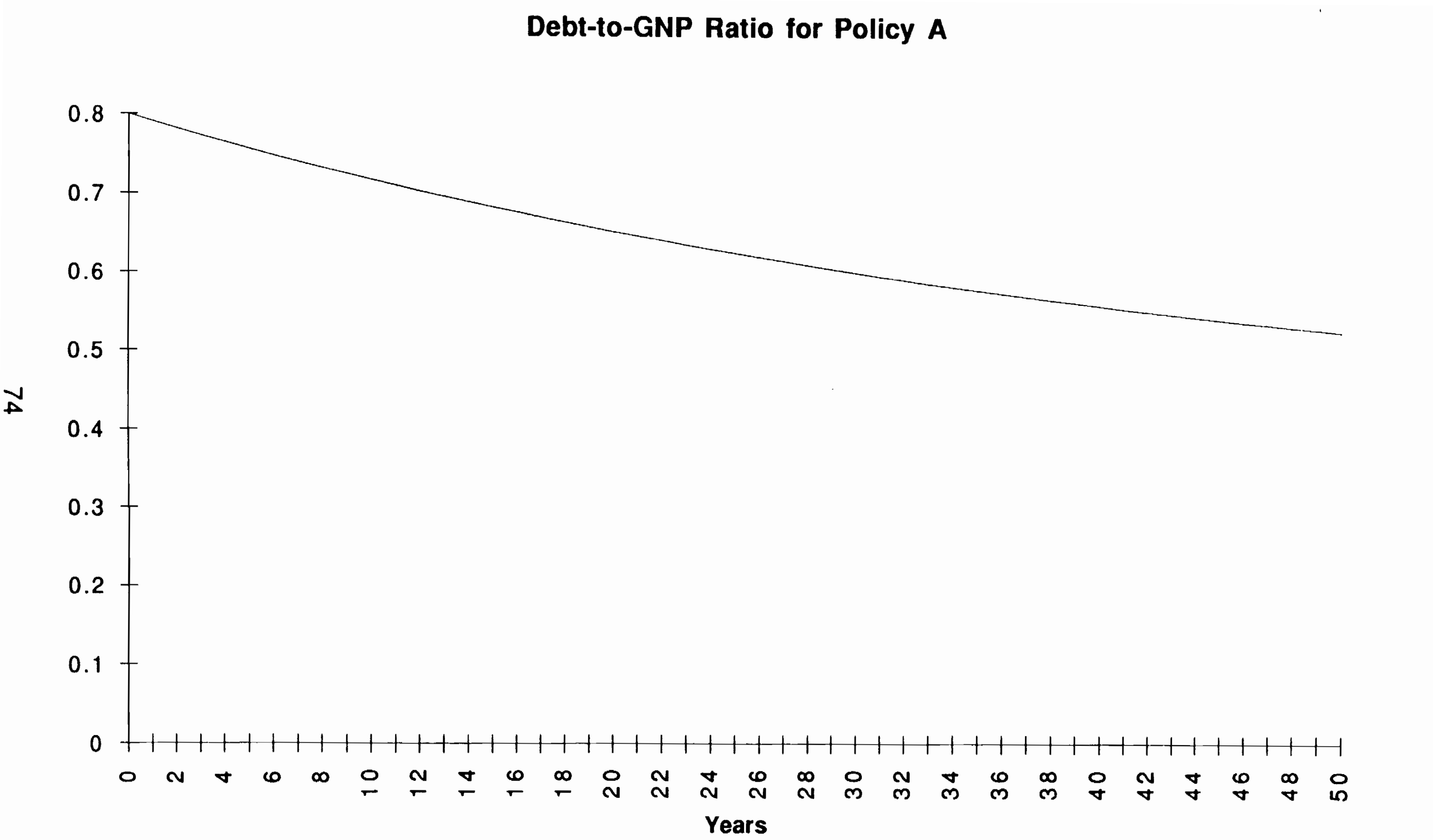

Figure 7. Debt to GNP ratio for Policy A.

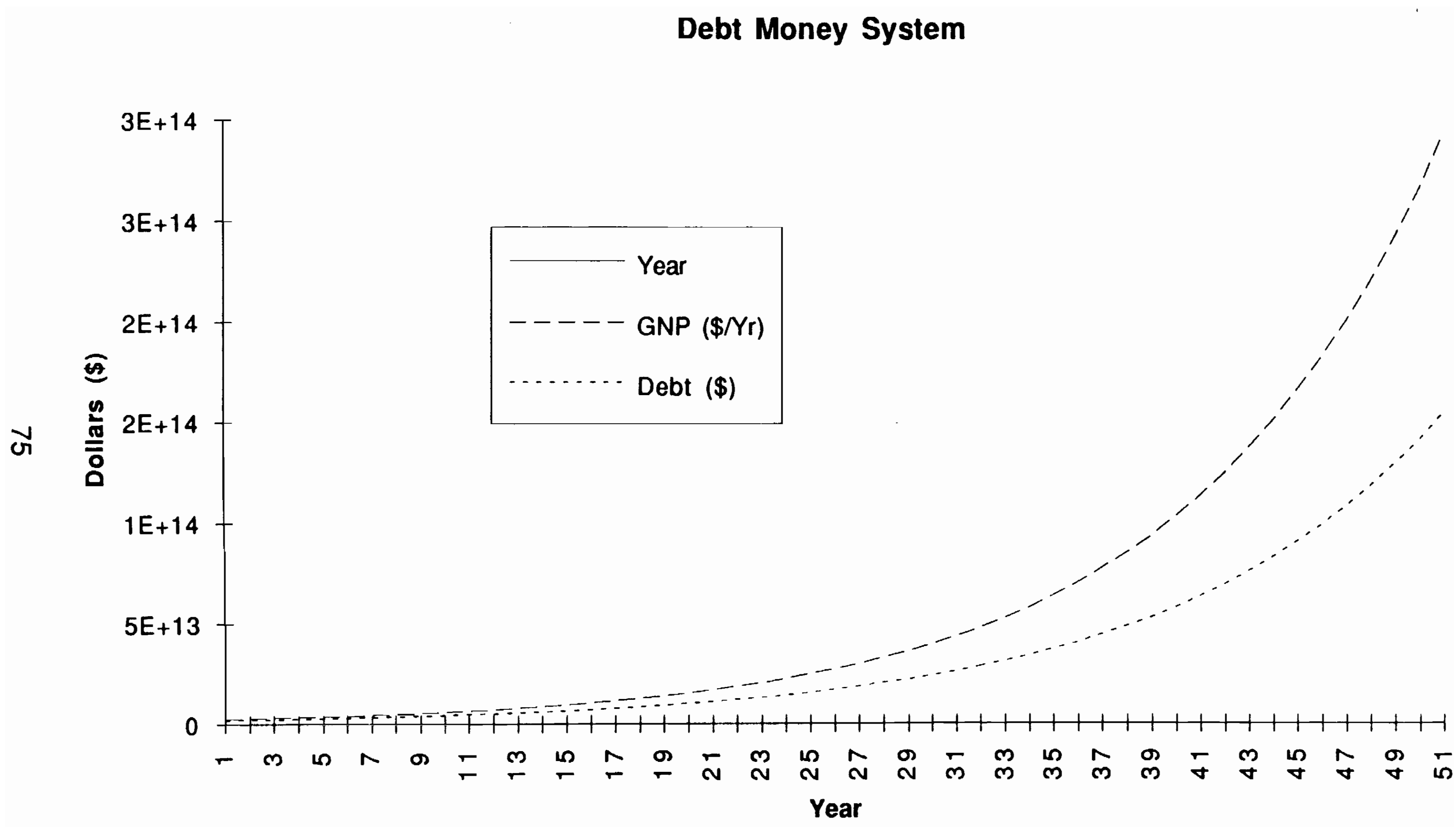

Figure 8. Debt money system, Policy A.

In the second trial of the debt money system model, called Policy B, a slightly less optimistic model is used. In this model, the fraction of budget to defense *(FBDF)* is increased from 20 percent to 25 percent. All other constants and initial values are the same as Policy A. The spreadsheet for Policy B is shown as Table 5. The effect of increasing defense spending without a corresponding reduction elsewhere is a more rapid growth of the debt than in the case of Policy A. This effect is demonstrated in Figure 9. Additionally, Figure 10 shows that the debt-to-GNP ratio declines much less rapidly than with Policy A. This is due to the fact that the GNP growth rate is unchanged from Policy A while the debt growth rate has increased. Once again, it is important to remember that this is a very simplified model, and the purpose of the model is to demonstrate the application of system dynamics to economic policy. A practical model would necessarily be much more complex , and it would be solved by DYNAMO.

Table 5. Debt money system Policy B.

Year	Capital ($)	CapInv ($/Yr)	GNP ($/Yr)	Output ($/Yr)	Debt ($)	Deficit ($/Yr)	Exp ($/Yr)	Rev ($/Yr)	FGNPT	Def ($/Yr)	SocSec ($/Yr)	Health ($/Yr)	Misc ($/Yr)	IOD ($/YR)	Debt/GNP
0	5.0000E+12	5E+11	2.5E+12	4.1667E+12	2.0000E+12	1.75E+11	6.75E+11	5E+11	0.2	1.25E+11	1.25E+11	1E+11	1.75E+11	1.5E+11	0.8
1	5.5000E+12	5.5E+11	2.75E+12	4.5833E+12	2.1750E+12	1.9063E+11	7.4063E+11	5.5E+11	0.2	1.375E+11	1.375E+11	1.1E+11	1.925E+11	1.6313E+11	0.79090909
2	6.0500E+12	6.05E+11	3.025E+12	5.0417E+12	2.3656E+12	2.0767E+11	8.1267E+11	6.05E+11	0.2	1.5125E+11	1.5125E+11	1.21E+11	2.1175E+11	1.7742E+11	0.78202479
3	6.6550E+12	6.655E+11	3.3275E+12	5.5458E+12	2.5733E+12	2.2627E+11	8.9177E+11	6.655E+11	0.2	1.6638E+11	1.6638E+11	1.331E+11	2.3293E+11	1.93E+11	0.77334241
4	7.3205E+12	7.3205E+11	3.6603E+12	6.1004E+12	2.7996E+12	2.4657E+11	9.7862E+11	7.3205E+11	0.2	1.8301E+11	1.8301E+11	1.4641E+11	2.5622E+11	2.0997E+11	0.76485736
5	8.0526E+12	8.0526E+11	4.0263E+12	6.7105E+12	3.0461E+12	2.6872E+11	1.074E+12	8.0526E+11	0.2	2.0131E+11	2.0131E+11	1.6105E+11	2.8184E+11	2.2846E+11	0.75656514
6	8.8578E+12	8.8578E+11	4.4289E+12	7.3815E+12	3.3149E+12	2.929E+11	1.1787E+12	8.8578E+11	0.2	2.2145E+11	2.2145E+11	1.7716E+11	3.1002E+11	2.4861E+11	0.74846139
7	9.7436E+12	9.7436E+11	4.8718E+12	8.1197E+12	3.6078E+12	3.193E+11	1.2937E+12	9.7436E+11	0.2	2.4359E+11	2.4359E+11	1.9487E+11	3.4103E+11	2.7058E+11	0.74054181
8	1.0718E+13	1.0718E+12	5.359E+12	8.9316E+12	3.9271E+12	3.4812E+11	1.4199E+12	1.0718E+12	0.2	2.6795E+11	2.6795E+11	2.1436E+11	3.7513E+11	2.9453E+11	0.73280223
9	1.1790E+13	1.179E+12	5.8949E+12	9.8248E+12	4.2752E+12	3.7959E+11	1.5586E+12	1.179E+12	0.2	2.9474E+11	2.9474E+11	2.3579E+11	4.1264E+11	3.2064E+11	0.72523854
10	1.2969E+13	1.2969E+12	6.4844E+12	1.0807E+13	4.6548E+12	4.1395E+11	1.7108E+12	1.2969E+12	0.2	3.2422E+11	3.2422E+11	2.5937E+11	4.539E+11	3.4911E+11	0.71784676
11	1.4266E+13	1.4266E+12	7.1328E+12	1.1888E+13	5.0687E+12	4.5148E+11	1.878E+12	1.4266E+12	0.2	3.5664E+11	3.5664E+11	2.8531E+11	4.993E+11	3.8015E+11	0.71062297
12	1.5692E+13	1.5692E+12	7.8461E+12	1.3077E+13	5.5202E+12	4.9248E+11	2.0617E+12	1.5692E+12	0.2	3.923E+11	3.923E+11	3.1384E+11	5.4922E+11	4.1402E+11	0.70356335
13	1.7261E+13	1.7261E+12	8.6307E+12	1.4384E+13	6.0127E+12	5.3726E+11	2.2634E+12	1.7261E+12	0.2	4.3153E+11	4.3153E+11	3.4523E+11	6.0415E+11	4.5095E+11	0.69666419
14	1.8987E+13	1.8987E+12	9.4937E+12	1.5823E+13	6.5499E+12	5.8618E+11	2.4849E+12	1.8987E+12	0.2	4.7469E+11	4.7469E+11	3.7975E+11	6.6456E+11	4.9125E+11	0.68992182
15	2.0886E+13	2.0886E+12	1.0443E+13	1.7405E+13	7.1361E+12	6.3964E+11	2.7283E+12	2.0886E+12	0.2	5.2216E+11	5.2216E+11	4.1772E+11	7.3102E+11	5.3521E+11	0.68333269
16	2.2975E+13	2.2975E+12	1.1487E+13	1.9146E+13	7.7758E+12	6.9806E+11	2.9955E+12	2.2975E+12	0.2	5.7437E+11	5.7437E+11	4.595E+11	8.0412E+11	5.8318E+11	0.67689331
17	2.5272E+13	2.5272E+12	1.2636E+13	2.106E+13	8.4738E+12	7.619E+11	3.2891E+12	2.5272E+12	0.2	6.3181E+11	6.3181E+11	5.0545E+11	8.8453E+11	6.3554E+11	0.67060028
18	2.7800E+13	2.78E+12	1.39E+13	2.3166E+13	9.2357E+12	8.3168E+11	3.6116E+12	2.78E+12	0.2	6.9499E+11	6.9499E+11	5.5599E+11	9.7299E+11	6.9268E+11	0.66445027
19	3.0580E+13	3.058E+12	1.529E+13	2.5483E+13	1.0067E+13	9.0795E+11	3.9659E+12	3.058E+12	0.2	7.6449E+11	7.6449E+11	6.1159E+11	1.0703E+12	7.5505E+11	0.65844004
20	3.3637E+13	3.3637E+12	1.6819E+13	2.8031E+13	1.0975E+13	9.9134E+11	4.3551E+12	3.3637E+12	0.2	8.4094E+11	8.4094E+11	6.7275E+11	1.1773E+12	8.2315E+11	0.6525664
21	3.7001E+13	3.7001E+12	1.8501E+13	3.0834E+13	1.1967E+13	1.0825E+12	4.7826E+12	3.7001E+12	0.2	9.2503E+11	9.2503E+11	7.4002E+11	1.295E+12	8.975E+11	0.64682625
22	4.0701E+13	4.0701E+12	2.0351E+13	3.3918E+13	1.3049E+13	1.1822E+12	5.2523E+12	4.0701E+12	0.2	1.0175E+12	1.0175E+12	8.1403E+11	1.4245E+12	9.7869E+11	0.64121657
23	4.4772E+13	4.4772E+12	2.2386E+13	3.731E+13	1.4231E+13	1.2912E+12	5.7684E+12	4.4772E+12	0.2	1.1193E+12	1.1193E+12	8.9543E+11	1.567E+12	1.0674E+12	0.63573437
24	4.9249E+13	4.9249E+12	2.4624E+13	4.1041E+13	1.5523E+13	1.4104E+12	6.3353E+12	4.9249E+12	0.2	1.2312E+12	1.2312E+12	9.8497E+11	1.7237E+12	1.1642E+12	0.63037677
25	5.4174E+13	5.4174E+12	2.7087E+13	4.5145E+13	1.6933E+13	1.5408E+12	6.9582E+12	5.4174E+12	0.2	1.3543E+12	1.3543E+12	1.0835E+12	1.8961E+12	1.27E+12	0.62514094
26	5.9591E+13	5.9591E+12	2.9795E+13	4.9659E+13	1.8474E+13	1.6835E+12	7.6426E+12	5.9591E+12	0.2	1.4898E+12	1.4898E+12	1.1918E+12	2.0857E+12	1.3855E+12	0.6200241
27	6.5550E+13	6.555E+12	3.2775E+13	5.4625E+13	2.0157E+13	1.8396E+12	8.3946E+12	6.555E+12	0.2	1.6387E+12	1.6387E+12	1.311E+12	2.2942E+12	1.5118E+12	0.61502355
28	7.2105E+13	7.2105E+12	3.6052E+13	6.0087E+13	2.1997E+13	2.0103E+12	9.2208E+12	7.2105E+12	0.2	1.8026E+12	1.8026E+12	1.4421E+12	2.5237E+12	1.6498E+12	0.61013665
29	7.9315E+13	7.9315E+12	3.9658E+13	6.6096E+13	2.4007E+13	2.1971E+12	1.0129E+13	7.9315E+12	0.2	1.9829E+12	1.9829E+12	1.5863E+12	2.776E+12	1.8005E+12	0.60536082
30	8.7247E+13	8.7247E+12	4.3624E+13	7.2706E+13	2.6204E+13	2.4016E+12	1.1126E+13	8.7247E+12	0.2	2.1812E+12	2.1812E+12	1.7449E+12	3.0536E+12	1.9653E+12	0.60069353
31	9.5972E+13	9.5972E+12	4.7986E+13	7.9976E+13	2.8606E+13	2.6253E+12	1.2222E+13	9.5972E+12	0.2	2.3993E+12	2.3993E+12	1.9194E+12	3.359E+12	2.1454E+12	0.59613231
32	1.0557E+14	1.0557E+13	5.2784E+13	8.7974E+13	3.1231E+13	2.8702E+12	1.3427E+13	1.0557E+13	0.2	2.6392E+12	2.6392E+12	2.1114E+12	3.6949E+12	2.3423E+12	0.59167476
33	1.1613E+14	1.1613E+13	5.8063E+13	9.6771E+13	3.4101E+13	3.1382E+12	1.4751E+13	1.1613E+13	0.2	2.9031E+12	2.9031E+12	2.3225E+12	4.0644E+12	2.5576E+12	0.58731851
34	1.2774E+14	1.2774E+13	6.3869E+13	1.0645E+14	3.7240E+13	3.4317E+12	1.6205E+13	1.2774E+13	0.2	3.1935E+12	3.1935E+12	2.5548E+12	4.4708E+12	2.793E+12	0.58306127
35	1.4051E+14	1.4051E+13	7.0256E+13	1.1709E+14	4.0671E+13	3.7529E+12	1.7804E+13	1.4051E+13	0.2	3.5128E+12	3.5128E+12	2.8102E+12	4.9179E+12	3.0503E+12	0.57890079
36	1.5456E+14	1.5456E+13	7.7282E+13	1.288E+14	4.4424E+13	4.1046E+12	1.9561E+13	1.5456E+13	0.2	3.8641E+12	3.8641E+12	3.0913E+12	5.4097E+12	3.3318E+12	0.57483486
37	1.7002E+14	1.7002E+13	8.501E+13	1.4168E+14	4.8529E+13	4.4896E+12	2.1492E+13	1.7002E+13	0.2	4.2505E+12	4.2505E+12	3.4004E+12	5.9507E+12	3.6397E+12	0.57086134
38	1.8702E+14	1.8702E+13	9.3511E+13	1.5585E+14	5.3019E+13	4.9115E+12	2.3614E+13	1.8702E+13	0.2	4.6755E+12	4.6755E+12	3.7404E+12	6.5458E+12	3.9764E+12	0.56697813
39	2.0572E+14	2.0572E+13	1.0286E+14	1.7144E+14	5.7930E+13	5.3734E+12	2.5946E+13	2.0572E+13	0.2	5.1431E+12	5.1431E+12	4.1145E+12	7.2003E+12	4.3448E+12	0.56318317
40	2.2630E+14	2.263E+13	1.1315E+14	1.8858E+14	6.3303E+13	5.8792E+12	2.8509E+13	2.263E+13	0.2	5.6574E+12	5.6574E+12	4.5259E+12	7.9204E+12	4.7478E+12	0.55947447
41	2.4893E+14	2.4893E+13	1.2446E+14	2.0744E+14	6.9183E+13	6.4333E+12	3.1326E+13	2.4893E+13	0.2	6.2231E+12	6.2231E+12	4.9785E+12	8.7124E+12	5.1887E+12	0.55585005
42	2.7382E+14	2.7382E+13	1.3691E+14	2.2818E+14	7.5616E+13	7.0403E+12	3.4422E+13	2.7382E+13	0.2	6.8455E+12	6.8455E+12	5.4764E+12	9.5836E+12	5.6712E+12	0.552308
43	3.0120E+14	3.012E+13	1.506E+14	2.51E+14	8.2656E+13	7.7052E+12	3.7825E+13	3.012E+13	0.2	7.53E+12	7.53E+12	6.024E+12	1.0542E+13	6.1992E+12	0.54884645
44	3.3132E+14	3.3132E+13	1.6566E+14	2.761E+14	9.0362E+13	8.4337E+12	4.1566E+13	3.3132E+13	0.2	8.283E+12	8.283E+12	6.6264E+12	1.1596E+13	6.7771E+12	0.54546358
45	3.6445E+14	3.6445E+13	1.8223E+14	3.0371E+14	9.8795E+13	9.2319E+12	4.5677E+13	3.6445E+13	0.2	9.1113E+12	9.1113E+12	7.289E+12	1.2756E+13	7.4096E+12	0.54215759
46	4.0090E+14	4.009E+13	2.0045E+14	3.3408E+14	1.0803E+14	1.0107E+13	5.0196E+13	4.009E+13	0.2	1.0022E+13	1.0022E+13	8.018E+12	1.4031E+13	8.102E+12	0.53892674
47	4.4099E+14	4.4099E+13	2.2049E+14	3.6749E+14	1.1813E+14	1.1065E+13	5.5164E+13	4.4099E+13	0.2	1.1025E+13	1.1025E+13	8.8197E+12	1.5435E+13	8.86E+12	0.53576931
48	4.8509E+14	4.8509E+13	2.4254E+14	4.0424E+14	1.2920E+14	1.2115E+13	6.0624E+13	4.8509E+13	0.2	1.2127E+13	1.2127E+13	9.7017E+12	1.6978E+13	9.6899E+12	0.53268364
49	5.3359E+14	5.3359E+13	2.668E+14	4.4466E+14	1.4131E+14	1.3267E+13	6.6626E+13	5.3359E+13	0.2	1.334E+13	1.334E+13	1.0672E+13	1.8676E+13	1.0599E+13	0.52966811
50	5.8695E+14	5.8695E+13	2.9348E+14	4.8913E+14	1.5458E+14	1.4528E+13	7.3224E+13	5.8695E+13	0.2	1.4674E+13	1.4674E+13	1.1739E+13	2.0543E+13	1.1594E+13	0.5267211

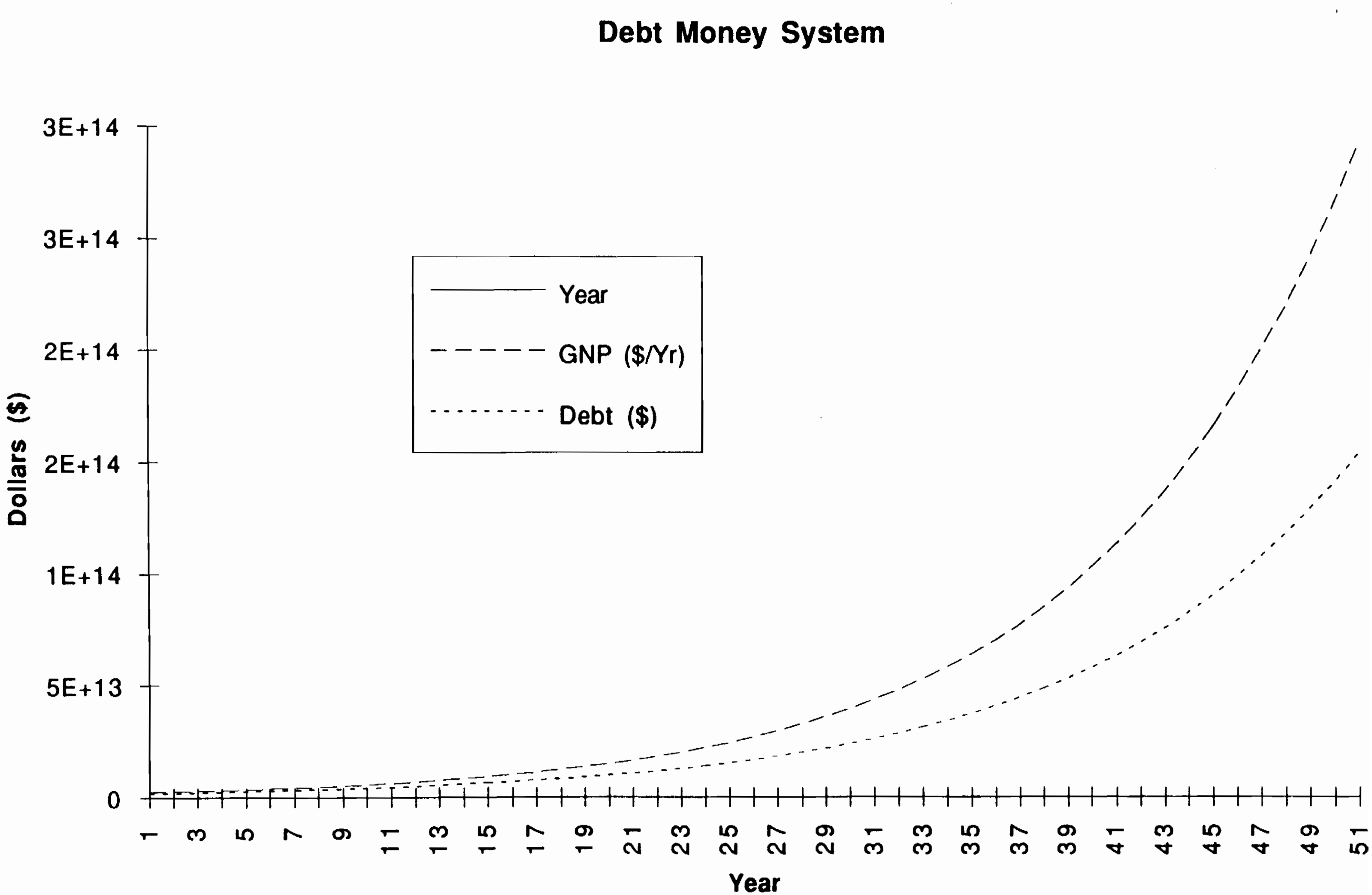

Figure 9. Debt money system, Policy B.

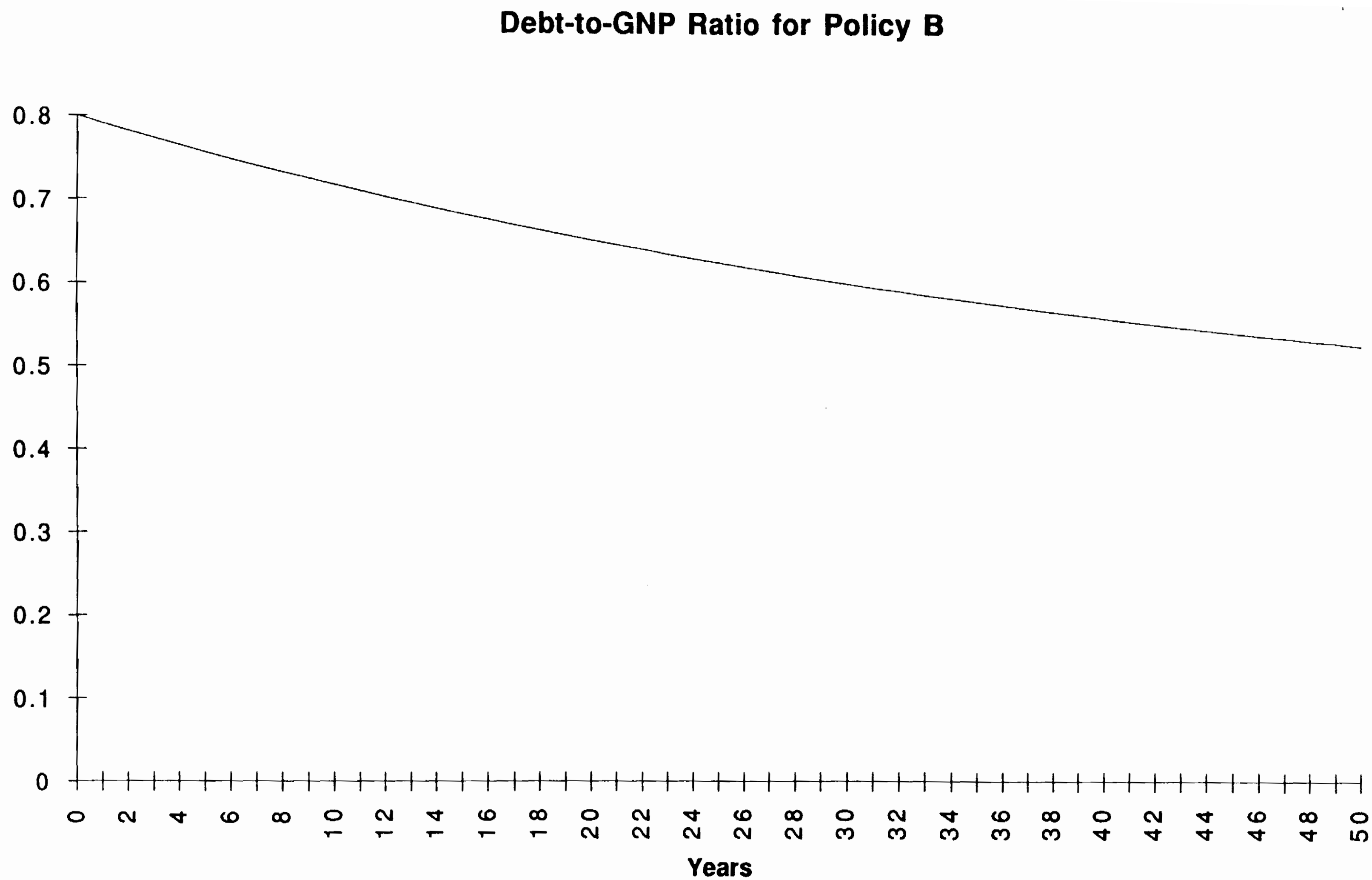

Figure 10. Debt to GNP ratio for Policy B.

In the third variation of the model, called Policy C, an even more pessimistic view is taken. The fraction of budget to defense is held at 25 percent, and the fraction of budget to health care *(FBHC)* is raised from 20 percent to 24 percent. Now the total proportion of revenues that is spent, excluding interest on the debt, is 109 percent. In the last fiscal year, the federal government spent over 120 percent of what it received in revenues. The spreadsheet for Policy C is shown as Table 6. An alarming debt growth rate is illustrated in Figure 11. Figure 12 shows a debt-to-GNP ratio that declines only slightly over 50 years.

The system dynamics method enables the policy maker to manipulate any of the constants, assumptions, or initial values of the model to experiment with various policies and outcomes. This is a very powerful technique that is used in this simple application to show the potential problem with the nation's current fiscal and monetary policies. These simple examples illustrate the consequences of adding to the compounding national debt with yearly budget deficits.

Table 6. Debt money system Policy C.

Year	Capital ($)	CapInv ($/Yr)	GNP ($/Yr)	Output ($/Yr)	Debt ($)	Deficit ($/Yr)	Exp ($/Yr)	Rev ($/Yr)	FGNPT	Def ($/Yr)	SocSec ($/Yr)	Health ($/Yr)	Misc ($/Yr)	IOD ($/YR)	Debt/GNP
0	5.0000E+12	5E+11	2.5E+12	4.1667E+12	2.0000E+12	1.95E+11	6.95E+11	5E+11	0.2	1.25E+11	1.25E+11	1.2E+11	1.75E+11	1.5E+11	0.8
1	5.5000E+12	5.5E+11	2.75E+12	4.5833E+12	2.1950E+12	2.1413E+11	7.6413E+11	5.5E+11	0.2	1.375E+11	1.375E+11	1.32E+11	1.925E+11	1.6463E+11	0.79818182
2	6.0500E+12	6.05E+11	3.025E+12	5.0417E+12	2.4091E+12	2.3513E+11	8.4013E+11	6.05E+11	0.2	1.5125E+11	1.5125E+11	1.452E+11	2.1175E+11	1.8068E+11	0.79640496
3	6.6550E+12	6.655E+11	3.3275E+12	5.5458E+12	2.6443E+12	2.5821E+11	9.2371E+11	6.655E+11	0.2	1.6638E+11	1.6638E+11	1.5972E+11	2.3293E+11	1.9832E+11	0.79466848
4	7.3205E+12	7.3205E+11	3.6603E+12	6.1004E+12	2.9025E+12	2.8357E+11	1.0156E+12	7.3205E+11	0.2	1.8301E+11	1.8301E+11	1.7569E+11	2.5622E+11	2.1769E+11	0.79297147
5	8.0526E+12	8.0526E+11	4.0263E+12	6.7105E+12	3.1860E+12	3.1143E+11	1.1167E+12	8.0526E+11	0.2	2.0131E+11	2.0131E+11	1.9326E+11	2.8184E+11	2.3895E+11	0.79131303
6	8.8578E+12	8.8578E+11	4.4289E+12	7.3815E+12	3.4975E+12	3.4203E+11	1.2278E+12	8.8578E+11	0.2	2.2145E+11	2.2145E+11	2.1259E+11	3.1002E+11	2.6231E+11	0.78969228
7	9.7436E+12	9.7436E+11	4.8718E+12	8.1197E+12	3.8395E+12	3.7565E+11	1.35E+12	9.7436E+11	0.2	2.4359E+11	2.4359E+11	2.3385E+11	3.4103E+11	2.8796E+11	0.78810836
8	1.0718E+13	1.0718E+12	5.359E+12	8.9316E+12	4.2152E+12	4.126E+11	1.4844E+12	1.0718E+12	0.2	2.6795E+11	2.6795E+11	2.5723E+11	3.7513E+11	3.1614E+11	0.78656045
9	1.1790E+13	1.179E+12	5.8949E+12	9.8248E+12	4.6278E+12	4.5319E+11	1.6322E+12	1.179E+12	0.2	2.9474E+11	2.9474E+11	2.8295E+11	4.1264E+11	3.4708E+11	0.78504771
10	1.2969E+13	1.2969E+12	6.4844E+12	1.0807E+13	5.0809E+12	4.9779E+11	1.7947E+12	1.2969E+12	0.2	3.2422E+11	3.2422E+11	3.1125E+11	4.539E+11	3.8107E+11	0.78356935
11	1.4266E+13	1.4266E+12	7.1328E+12	1.1888E+13	5.5787E+12	5.468E+11	1.9734E+12	1.4266E+12	0.2	3.5664E+11	3.5664E+11	3.4237E+11	4.993E+11	4.184E+11	0.78212459
12	1.5692E+13	1.5692E+12	7.8461E+12	1.3077E+13	6.1255E+12	6.0064E+11	2.1699E+12	1.5692E+12	0.2	3.923E+11	3.923E+11	3.7661E+11	5.4922E+11	4.5941E+11	0.78071267
13	1.7261E+13	1.7261E+12	8.6307E+12	1.4384E+13	6.7262E+12	6.5982E+11	2.386E+12	1.7261E+12	0.2	4.3153E+11	4.3153E+11	4.1427E+11	6.0415E+11	5.0446E+11	0.77933284
14	1.8987E+13	1.8987E+12	9.4937E+12	1.5823E+13	7.3860E+12	7.2484E+11	2.6236E+12	1.8987E+12	0.2	4.7469E+11	4.7469E+11	4.557E+11	6.6456E+11	5.5395E+11	0.77798436
15	2.0886E+13	2.0886E+12	1.0443E+13	1.7405E+13	8.1108E+12	7.9629E+11	2.8849E+12	2.0886E+12	0.2	5.2216E+11	5.2216E+11	5.0127E+11	7.3102E+11	6.0831E+11	0.77666654
16	2.2975E+13	2.2975E+12	1.1487E+13	1.9146E+13	8.9071E+12	8.7481E+11	3.1723E+12	2.2975E+12	0.2	5.7437E+11	5.7437E+11	5.514E+11	8.0412E+11	6.6803E+11	0.77537866
17	2.5272E+13	2.5272E+12	1.2636E+13	2.106E+13	9.7819E+12	9.6109E+11	3.4883E+12	2.5272E+12	0.2	6.3181E+11	6.3181E+11	6.0654E+11	8.8453E+11	7.3364E+11	0.77412006
18	2.7800E+13	2.78E+12	1.39E+13	2.3166E+13	1.0743E+13	1.0559E+12	3.8359E+12	2.78E+12	0.2	6.9499E+11	6.9499E+11	6.6719E+11	9.7299E+11	8.0573E+11	0.77289005
19	3.0580E+13	3.058E+12	1.529E+13	2.5483E+13	1.1799E+13	1.1601E+12	4.2181E+12	3.058E+12	0.2	7.6449E+11	7.6449E+11	7.3391E+11	1.0703E+12	8.8492E+11	0.77168801
20	3.3637E+13	3.3637E+12	1.6819E+13	2.8031E+13	1.2959E+13	1.2747E+12	4.6384E+12	3.3637E+12	0.2	8.4094E+11	8.4094E+11	8.073E+11	1.1773E+12	9.7193E+11	0.77051328
21	3.7001E+13	3.7001E+12	1.8501E+13	3.0834E+13	1.4234E+13	1.4005E+12	5.1007E+12	3.7001E+12	0.2	9.2503E+11	9.2503E+11	8.8803E+11	1.295E+12	1.0675E+12	0.76936525
22	4.0701E+13	4.0701E+12	2.0351E+13	3.3918E+13	1.5634E+13	1.5389E+12	5.609E+12	4.0701E+12	0.2	1.0175E+12	1.0175E+12	9.7683E+11	1.4245E+12	1.1726E+12	0.76824331
23	4.4772E+13	4.4772E+12	2.2386E+13	3.731E+13	1.7173E+13	1.6909E+12	6.1681E+12	4.4772E+12	0.2	1.1193E+12	1.1193E+12	1.0745E+12	1.567E+12	1.288E+12	0.76714687
24	4.9249E+13	4.9249E+12	2.4624E+13	4.1041E+13	1.8864E+13	1.858E+12	6.7829E+12	4.9249E+12	0.2	1.2312E+12	1.2312E+12	1.182E+12	1.7237E+12	1.4148E+12	0.76607535
25	5.4174E+13	5.4174E+12	2.7087E+13	4.5145E+13	2.0722E+13	2.0417E+12	7.4591E+12	5.4174E+12	0.2	1.3543E+12	1.3543E+12	1.3002E+12	1.8961E+12	1.5542E+12	0.76502819
26	5.9591E+13	5.9591E+12	2.9795E+13	4.9659E+13	2.2764E+13	2.2436E+12	8.2027E+12	5.9591E+12	0.2	1.4898E+12	1.4898E+12	1.4302E+12	2.0857E+12	1.7073E+12	0.76400482
27	6.5550E+13	6.555E+12	3.2775E+13	5.4625E+13	2.5007E+13	2.4655E+12	9.0205E+12	6.555E+12	0.2	1.6387E+12	1.6387E+12	1.5732E+12	2.2942E+12	1.8756E+12	0.76300471
28	7.2105E+13	7.2105E+12	3.6052E+13	6.0087E+13	2.7473E+13	2.7094E+12	9.9199E+12	7.2105E+12	0.2	1.8026E+12	1.8026E+12	1.7305E+12	2.5237E+12	2.0605E+12	0.76202733
29	7.9315E+13	7.9315E+12	3.9658E+13	6.6096E+13	3.0182E+13	2.9775E+12	1.0909E+13	7.9315E+12	0.2	1.9829E+12	1.9829E+12	1.9036E+12	2.776E+12	2.2637E+12	0.76107216
30	8.7247E+13	8.7247E+12	4.3624E+13	7.2706E+13	3.3160E+13	3.2722E+12	1.1997E+13	8.7247E+12	0.2	2.1812E+12	2.1812E+12	2.0939E+12	3.0536E+12	2.487E+12	0.76013871
31	9.5972E+13	9.5972E+12	4.7986E+13	7.9976E+13	3.6432E+13	3.5962E+12	1.3193E+13	9.5972E+12	0.2	2.3993E+12	2.3993E+12	2.3033E+12	3.359E+12	2.7324E+12	0.75922646
32	1.0557E+14	1.0557E+13	5.2784E+13	8.7974E+13	4.0028E+13	3.9522E+12	1.4509E+13	1.0557E+13	0.2	2.6392E+12	2.6392E+12	2.5337E+12	3.6949E+12	3.0021E+12	0.75833495
33	1.1613E+14	1.1613E+13	5.8063E+13	9.6771E+13	4.3981E+13	4.3437E+12	1.5956E+13	1.1613E+13	0.2	2.9031E+12	2.9031E+12	2.787E+12	4.0644E+12	3.2985E+12	0.7574637
34	1.2774E+14	1.2774E+13	6.3869E+13	1.0645E+14	4.8324E+13	4.774E+12	1.7548E+13	1.2774E+13	0.2	3.1935E+12	3.1935E+12	3.0657E+12	4.4708E+12	3.6243E+12	0.75661225
35	1.4051E+14	1.4051E+13	7.0256E+13	1.1709E+14	5.3098E+13	5.247E+12	1.9298E+13	1.4051E+13	0.2	3.5128E+12	3.5128E+12	3.3723E+12	4.9179E+12	3.9824E+12	0.75578016
36	1.5456E+14	1.5456E+13	7.7282E+13	1.288E+14	5.8345E+13	5.767E+12	2.1223E+13	1.5456E+13	0.2	3.8641E+12	3.8641E+12	3.7095E+12	5.4097E+12	4.3759E+12	0.75496697
37	1.7002E+14	1.7002E+13	8.501E+13	1.4168E+14	6.4112E+13	6.3386E+12	2.3341E+13	1.7002E+13	0.2	4.2505E+12	4.2505E+12	4.0805E+12	5.9507E+12	4.8084E+12	0.75417227
38	1.8702E+14	1.8702E+13	9.3511E+13	1.5585E+14	7.0451E+13	6.967E+12	2.5669E+13	1.8702E+13	0.2	4.6755E+12	4.6755E+12	4.4885E+12	6.5458E+12	5.2838E+12	0.75339563
39	2.0572E+14	2.0572E+13	1.0286E+14	1.7144E+14	7.7418E+13	7.6578E+12	2.823E+13	2.0572E+13	0.2	5.1431E+12	5.1431E+12	4.9374E+12	7.2003E+12	5.8063E+12	0.75263663
40	2.2630E+14	2.263E+13	1.1315E+14	1.8858E+14	8.5076E+13	8.4173E+12	3.1047E+13	2.263E+13	0.2	5.6574E+12	5.6574E+12	5.4311E+12	7.9204E+12	6.3807E+12	0.75189489
41	2.4893E+14	2.4893E+13	1.2446E+14	2.0744E+14	9.3493E+13	9.2523E+12	3.4145E+13	2.4893E+13	0.2	6.2231E+12	6.2231E+12	5.9742E+12	8.7124E+12	7.012E+12	0.75117001
42	2.7382E+14	2.7382E+13	1.3691E+14	2.2818E+14	1.0275E+14	1.017E+13	3.7552E+13	2.7382E+13	0.2	6.8455E+12	6.8455E+12	6.5716E+12	9.5836E+12	7.7059E+12	0.7504616
43	3.0120E+14	3.012E+13	1.506E+14	2.51E+14	1.1292E+14	1.1179E+13	4.1299E+13	3.012E+13	0.2	7.53E+12	7.53E+12	7.2288E+12	1.0542E+13	8.4687E+12	0.74976929
44	3.3132E+14	3.3132E+13	1.6566E+14	2.761E+14	1.2409E+14	1.2289E+13	4.5421E+13	3.3132E+13	0.2	8.283E+12	8.283E+12	7.9517E+12	1.1596E+13	9.3071E+12	0.74909272
45	3.6445E+14	3.6445E+13	1.8223E+14	3.0371E+14	1.3638E+14	1.3509E+13	4.9954E+13	3.6445E+13	0.2	9.1113E+12	9.1113E+12	8.7469E+12	1.2756E+13	1.0229E+13	0.74843152
46	4.0090E+14	4.009E+13	2.0045E+14	3.3408E+14	1.4989E+14	1.485E+13	5.494E+13	4.009E+13	0.2	1.0022E+13	1.0022E+13	9.6215E+12	1.4031E+13	1.1242E+13	0.74778535
47	4.4099E+14	4.4099E+13	2.2049E+14	3.6749E+14	1.6474E+14	1.6325E+13	6.0423E+13	4.4099E+13	0.2	1.1025E+13	1.1025E+13	1.0584E+13	1.5435E+13	1.2356E+13	0.74715386
48	4.8509E+14	4.8509E+13	2.4254E+14	4.0424E+14	1.8107E+14	1.7946E+13	6.6454E+13	4.8509E+13	0.2	1.2127E+13	1.2127E+13	1.1642E+13	1.6978E+13	1.358E+13	0.74653673
49	5.3359E+14	5.3359E+13	2.668E+14	4.4466E+14	1.9901E+14	1.9728E+13	7.3088E+13	5.3359E+13	0.2	1.334E+13	1.334E+13	1.2806E+13	1.8676E+13	1.4926E+13	0.74593362
50	5.8695E+14	5.8695E+13	2.9348E+14	4.8913E+14	2.1874E+14	2.1688E+13	8.0384E+13	5.8695E+13	0.2	1.4674E+13	1.4674E+13	1.4087E+13	2.0543E+13	1.6406E+13	0.74534422

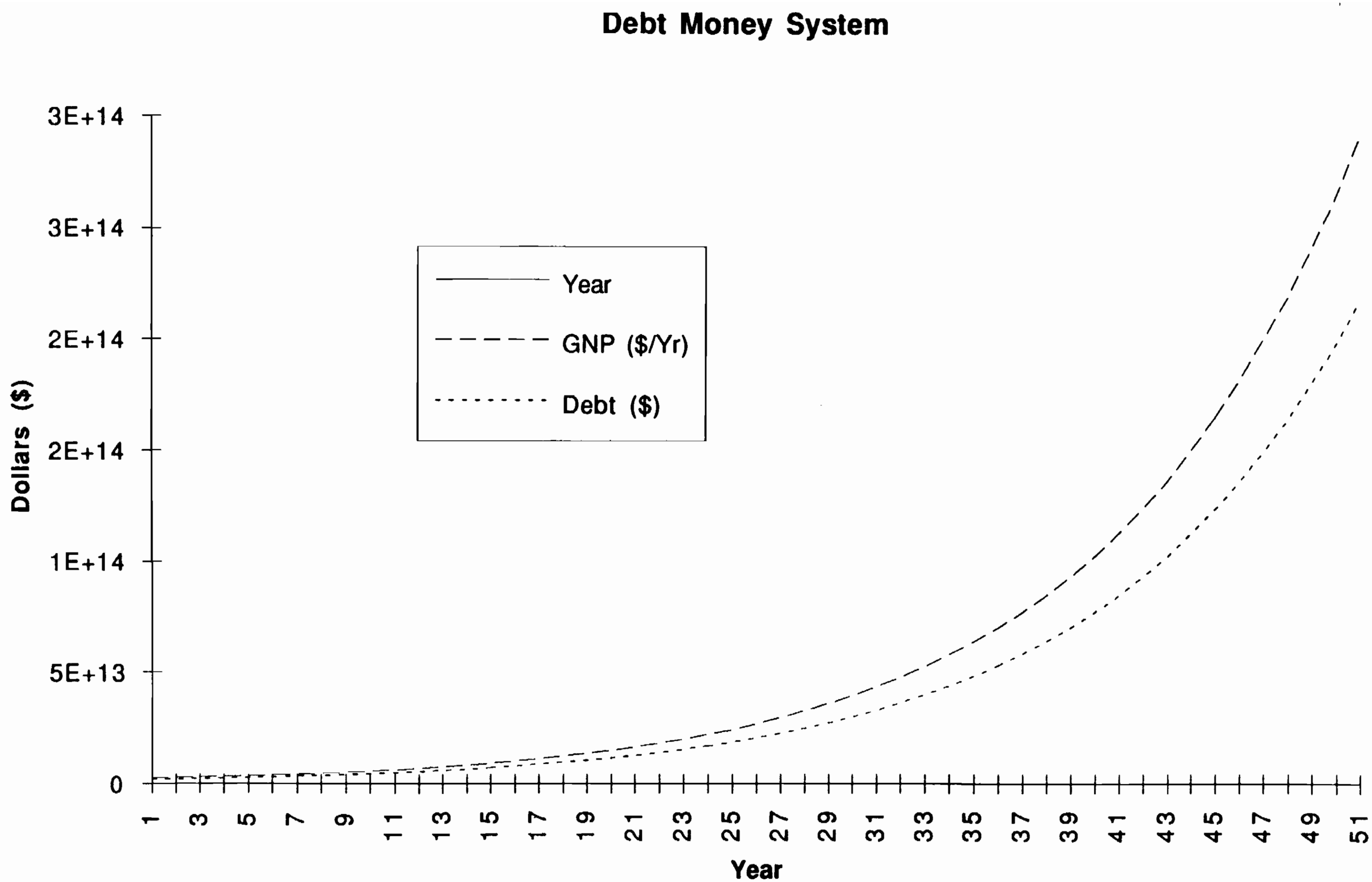

Figure 11. Debt money system, Policy C.

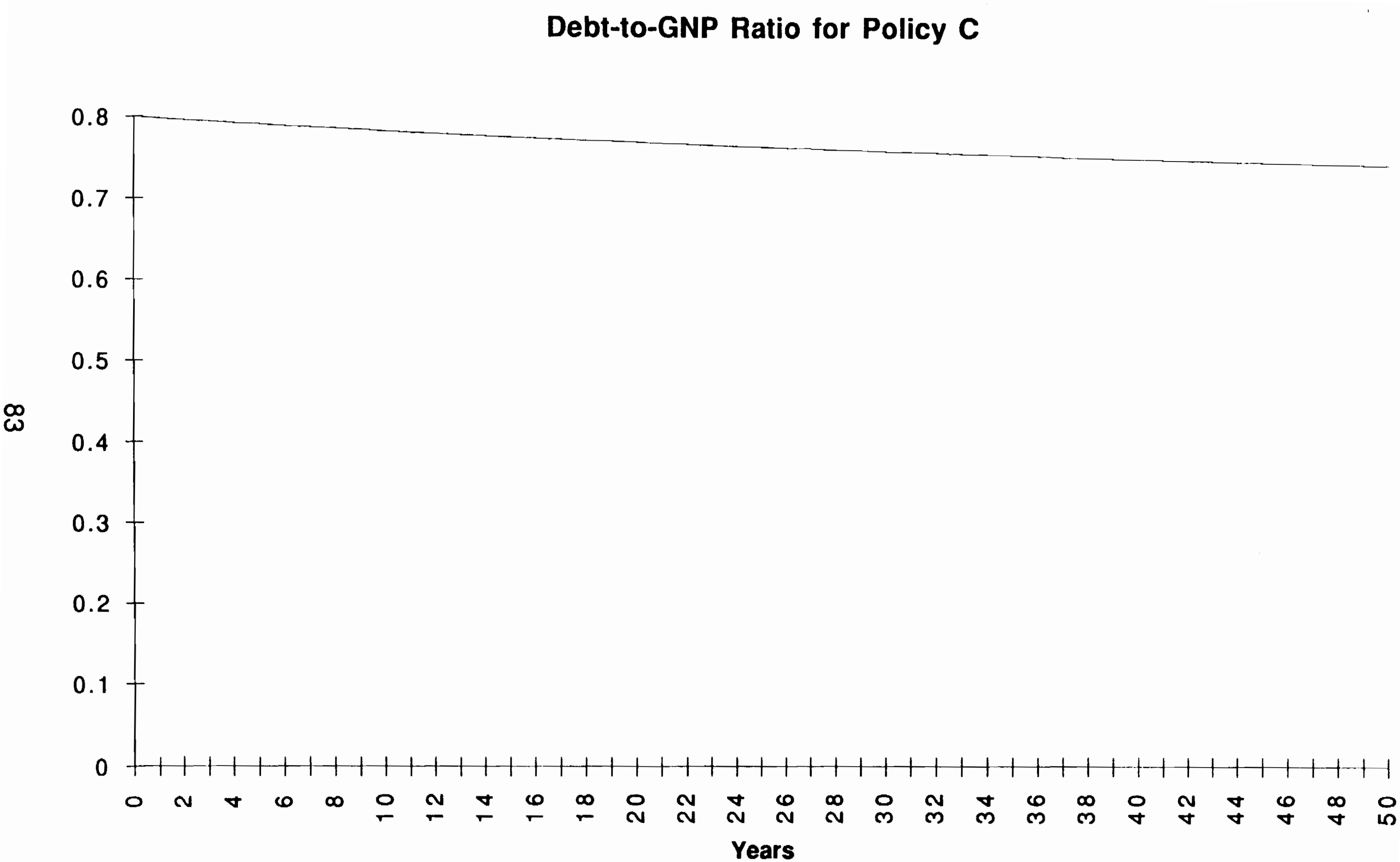

Figure 12. Debt to GNP ratio for Policy C.

5.8 The Treasury Credit Money System

A possible solution to the debt money system has been used in this country once before. In 1861, President Lincoln was attempting to finance the North's war effort. The interest rates that were quoted by the bankers to the President were all prohibitively high. He was faced with a terrible dilemma: he needed money to finance the war, but he knew that the troubled government could not afford the high interest rates. After working closely with Congress on this issue, the President signed legislation that allowed the Treasury to spend 60 million dollars into existence debt-free.[36] That single act likely saved the country billions of dollars worth of interest payments.

Such a system of debt-free expenditure could be permanently implemented today to rid the nation of the rising debt problems. Congress has the Constitutional authority to take such action. Instead of private banks creating money through expansion of their reserves and the Federal Reserve controlling interest rates and other monetary policy, the central monetary authority in such a system would be the Treasury. Only the Treasury would be able to create money. Hence, the name of this system is the Treasury Credit Money System (TCMS).[37]

5.8.1 The Basic Principles of the TCMS

The TCMS is built on several important principles. Most importantly, the Treasury is the sole creator of cash money and universal money credit. The

Treasury provides debt-free public funds for all needed, achievable, and authorized expenditures of the federal government. The Treasury also provides for the credit needs of the private sector with loans to banks. The banks will loan money based upon their customers' savings, investment earnings, service charges and the like. Banks will not create money. The Treasury lends directly to private entities when special circumstances warrant such action, and it also makes interest-free loans to State and local public treasuries for voter-approved expenditures. With the TCMS, government revenues and debt-free expenditures are maintained in an approximate balance. The money that is spent into circulation by the Treasury is eventually returned to the Treasury and removed from circulation.[38]

A Treasury Credit Money System is stable because the supply of money is always greater than the total debt. Interest rates and government revenues are controlled to balance the flow of interest and taxes with the flow of debt-free, government expenditure. The balance associated with the TCMS serves to eliminate severe, cyclical, economic fluctuations.

In the TCMS, money is created and injected into the economy in two ways:

1. Debt-free public expenditure
2. Private sector Treasury loans.

Money flows back to the Treasury as principal and interest on loans made to the private sector and as taxes. This money that flows back to the Treasury is destroyed. The combination of debt-free expenditures, interest, and taxes is regulated to maintain a slight excess of money in the system. Therefore, the total debt could never exceed the total money supply, as is the case today with the debt money system.

The following are examples of the many benefits of adopting the TCMS:

- Federal income taxes are drastically reduced since most of federal spending is debt-free.
- State and local taxes are reduced, since interest-free Treasury loans are available.
- Interest rates are lower and credit is always available to businesses and individuals.
- Inflation due to the endless borrowing cycle of the debt money system is reduced.
- Private debt can be paid off from the existing money supply.
- The economy is much less vulnerable to boom-and-bust business cycles.
- Usury is removed from the monetary system.
- Federal borrowing stops, and the federal deficit is eliminated.
- The multi-trillion dollar national debt and its huge interest load are reduced to zero.
- The banking system is stabilized, and the threat of economic collapse is eliminated.[39]

Of course, a TCMS would have to be established by an Act of Congress. The highlights of such legislation would likely include:

- The United States Treasury shall be the only source of original monetary issue.

- The Federal Reserve Act of 1913 is repealed. The Federal Reserve Banks' assets are turned over to the Treasury.
- Private banks, institutions, and individuals are prohibited from creating money.
- The interest rate charged by the Treasury on all loans to the private sector shall be set such that money is withdrawn from circulation at a rate necessary to maintain a balance with expenditures. Taxes will be used as needed to withdraw excess money from circulation.
- Federal government borrowing is prohibited.[40]

The most serious difficulty a policy maker may have with supporting the adoption of the TCMS is the question of the transition. The TCMS is certainly a radical departure to the current ways of doing business. However, once the commitment is made to the ideals that the Treasury is the only money creator and that Treasury expenditures entail debt-free creation of money, the remainder of the transition is quite logical. The system dynamics process can illustrate the effects of the transition to the TCMS.

5.8.2 System Dynamics and the TCMS

The first step in the creation of the system dynamics model is to construct a verbal model or description of the system. The total money supply in circulation equals the total debt to the Treasury plus the total amount of Treasury-spent funds in circulation. Many of the decisions of the TCMS depend upon the desired growth rate of the money supply. Therefore, a money supply growth rate over the time extent of the model should be chosen. Anticipated annual Treasury expenditures and loans should be defined. The interest rate should also be defined. Since one of the design objectives of the TCMS is to balance debt-free Treasury expenditure with interest plus taxes according to

$$e = i+t, \tag{8}$$

where e represents annual Treasury expenditure, i is the annual interest income, and t is the annual tax revenue, the interest rate may be chosen such that taxes are equal to zero. The interest rate may also be assumed to be any reasonable value, such as 10 percent.[41] The interest payment for any year equals the debt multiplied by the interest rate. Initially taxes are set equal to zero. The required principal payment on debt to the Treasury is equal to annual Treasury expenditure, plus Treasury loans, minus the growth of the supply of money, minus the interest payment. The change in debt is the Treasury loans minus the payment of Treasury principal. The debt is the initial value of the debt plus the change in debt. As the debt is reduced, a point is reached where the principal is equal to the debt for that year. From that point on, the annual federal tax revenue is equal to the annual Treasury expenditure, plus Treasury loans, minus the change in the supply of money, minus interest payments, minus the debt.

The verbal description is then used to build a causal diagram. The causal diagram for the TCMS is given in Figure 13. This causal diagram has two levels and two, first-order, positive feedback loops. Note that this causal diagram shows the variable T for taxes even though taxes are defined to be zero until principal equals debt. The next step in the system dynamics analysis is to create the difference equations of the system so that its dynamic behavior can be explored. The difference equations for the TCMS model are given in Table 7.

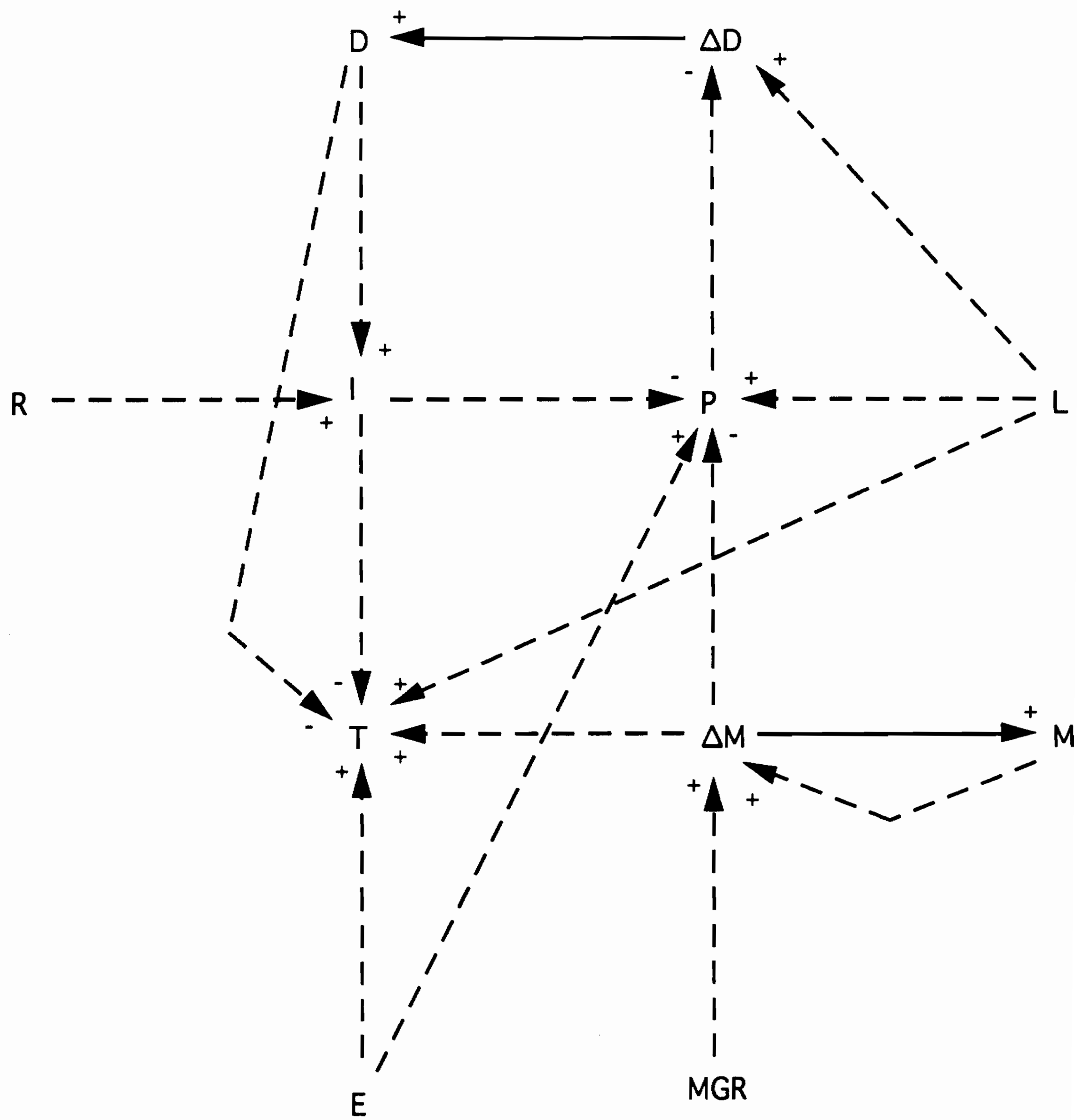

Figure 13. TCMS causal diagram.

Table 7. System dynamics equations for TCMS.

SYSTEM DYNAMICS EQ.	KEY
D.K=D.J+DT(ΔD.JK)	D - DEBT ($)
DN=2.9E12	DN - DEBT INITIAL VALUE ($)
ΔD.JK=L-P.K	ΔD - CHANGE IN DEBT ($/YR)
L=1.5E11	L - TREASURY LOANS ($/YR)
P.K=E+L-ΔM.K-I.K	P - PRINCIPAL PAYMENTS ($/YR)
I.K=D.K*R	I - INTEREST ($/YR)
R=.10	R- INTEREST RATE (DIM)
E=1.0E12	E - TREASURY EXPENDITURE ($/YR)
T.K=E+L-ΔM-I.K-D.K	T - TAX ($/YR)
ΔM.K=M.K*MGR	ΔM - CHANGE IN MONEY SUPPLY ($/YR)
M.K=M.J+(DT)(ΔM.K)	M - MONEY SUPPLY ($)
MN=9.0E11	MN - MONEY SUPPLY INITIAL VALUE ($)
MGR=.0526	MONEY SUPPLY GROWTH RATE (DIM)

The system dynamics equations of Table 7 do not yield a simple numerical solution, so a spreadsheet is used once again to help analyze the system's dynamic behavior. A spreadsheet of the first run of the system dynamics model, Policy A, is shown in Table 8. Note that the debt is reduced to the value of new loan principal within four years. Figure 14 is a plot of three key variables of Table 8, debt, money supply, and taxes. This figure illustrates how quickly the TCMS reduces the debt while steadily growing the money supply and maintaining a slightly declining taxation policy. The declining rate of taxation is caused by holding expenditures constant while growing the money supply at 5.26 percent, which is admittedly a gross simplification. Again, the key point is the demonstrated use of the model rather than the absolute values of the results. The variables can always be disaggregated and analyzed using a powerful computer.

For the second run of the model, Policy B, the money supply growth rate is reduced to 3 percent. The spreadsheet for Policy B is shown in Table 9. Once again, the debt is quickly reduced to the annual Treasury loan amount. A plot of TCMS Policy B is shown in Figure 15. The tax rate is higher in this example than in Policy A because the money growth rate is lower, which necessitates a higher tax rate to remove the excess money from the system.

The spreadsheet for the final run of the TCMS, Policy C, is shown in Table 10. For this example, the interest rate is raised to 15 percent, the money supply growth rate is raised to 6 percent, and expenditures are increased at an annual rate of 2 percent. Once again, the debt is rapidly eliminated. Figure 16 is a plot of TCMS Policy C. This plot shows that taxes are increasing with this scenario. The cause of the rising taxes is the 2 percent annual rise in Treasury expenditures.

Table 8. TCMS Policy A.

Year	Debt	Δ Debt	loans	principle	exp	Δ Money	interest	intrate	Money Supply	MGR	tax
0	2.9000E+12	-6.6266E+11	1.5000E+11	8.1266E+11	1.0000E+12	4.7340E+10	2.9000E+11	0.1	9.0000E+11	0.0526	0.0000E+00
1	2.2373E+12	-7.2644E+11	1.5000E+11	8.7644E+11	1.0000E+12	4.9830E+10	2.2373E+11	0.1	9.4734E+11	0.0526	0.0000E+00
2	1.5109E+12	-7.9646E+11	1.5000E+11	9.4646E+11	1.0000E+12	5.2451E+10	1.5109E+11	0.1	9.9717E+11	0.0526	0.0000E+00
3	7.1445E+11	-5.6445E+11	1.5000E+11	7.1445E+11	1.0000E+12	5.5210E+10	7.1445E+10	0.1	1.0496E+12	0.0526	3.0890E+11
4	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	5.8114E+10	1.5000E+10	0.1	1.1048E+12	0.0526	9.2689E+11
5	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	6.1171E+10	1.5000E+10	0.1	1.1629E+12	0.0526	9.2383E+11
6	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	6.4389E+10	1.5000E+10	0.1	1.2241E+12	0.0526	9.2061E+11
7	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	6.7775E+10	1.5000E+10	0.1	1.2885E+12	0.0526	9.1722E+11
8	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	7.1340E+10	1.5000E+10	0.1	1.3563E+12	0.0526	9.1366E+11
9	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	7.5093E+10	1.5000E+10	0.1	1.4276E+12	0.0526	9.0991E+11
10	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	7.9043E+10	1.5000E+10	0.1	1.5027E+12	0.0526	9.0596E+11
11	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	8.3200E+10	1.5000E+10	0.1	1.5818E+12	0.0526	9.0180E+11
12	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	8.7577E+10	1.5000E+10	0.1	1.6650E+12	0.0526	8.9742E+11
13	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	9.2183E+10	1.5000E+10	0.1	1.7525E+12	0.0526	8.9282E+11
14	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	9.7032E+10	1.5000E+10	0.1	1.8447E+12	0.0526	8.8797E+11
15	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.0214E+11	1.5000E+10	0.1	1.9417E+12	0.0526	8.8286E+11
16	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.0751E+11	1.5000E+10	0.1	2.0439E+12	0.0526	8.7749E+11
17	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.1316E+11	1.5000E+10	0.1	2.1514E+12	0.0526	8.7184E+11
18	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.1912E+11	1.5000E+10	0.1	2.2646E+12	0.0526	8.6588E+11
19	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.2538E+11	1.5000E+10	0.1	2.3837E+12	0.0526	8.5962E+11
20	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.3198E+11	1.5000E+10	0.1	2.5091E+12	0.0526	8.5302E+11
21	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.3892E+11	1.5000E+10	0.1	2.6410E+12	0.0526	8.4608E+11
22	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.4623E+11	1.5000E+10	0.1	2.7799E+12	0.0526	8.3877E+11
23	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.5392E+11	1.5000E+10	0.1	2.9262E+12	0.0526	8.3108E+11
24	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.6201E+11	1.5000E+10	0.1	3.0801E+12	0.0526	8.2299E+11
25	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	1.7053E+11	1.5000E+10	0.1	3.2421E+12	0.0526	8.1447E+11

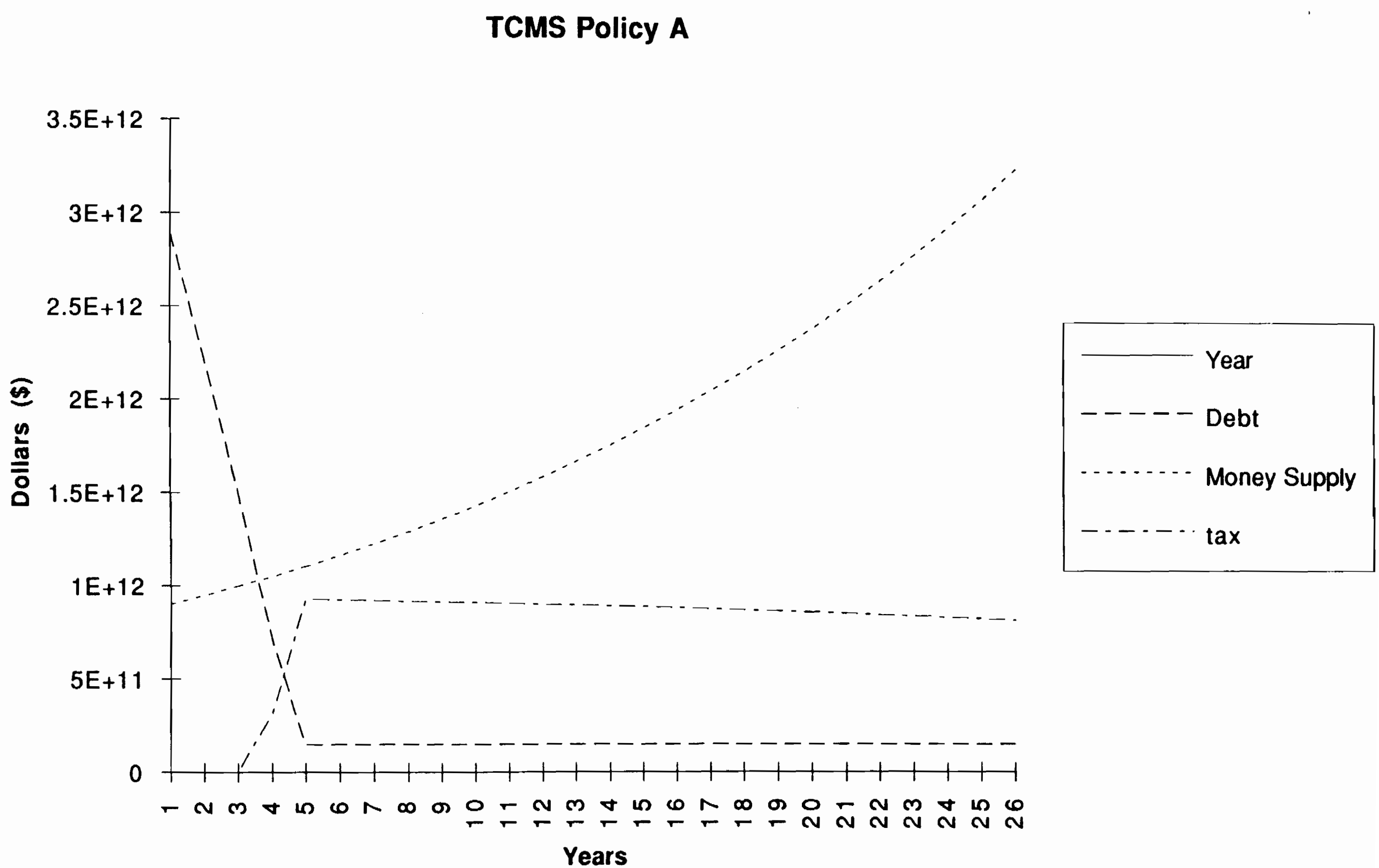

Figure 14. TCMS Policy A.

Table 9. TCMS Policy B.

Year	Debt	Δ Debt	loans	principle	exp	Δ Money	interest	intrate	Money Supply	MGR	tax
0	2.9000E+12	-6.83E+11	1.5000E+11	8.3300E+11	1.0000E+12	2.7000E+10	2.9000E+11	0.1	9.0000E+11	0.03	0.0000E+00
1	2.2170E+12	-7.5049E+11	1.5000E+11	9.0049E+11	1.0000E+12	2.7810E+10	2.2170E+11	0.1	9.2700E+11	0.03	0.0000E+00
2	1.4665E+12	-8.247E+11	1.5000E+11	9.7470E+11	1.0000E+12	2.8644E+10	1.4665E+11	0.1	9.5481E+11	0.03	0.0000E+00
3	6.4181E+11	-4.9181E+11	1.5000E+11	6.4181E+11	1.0000E+12	2.9504E+10	6.4181E+10	0.1	9.8345E+11	0.03	4.1451E+11
4	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.0389E+10	1.5000E+10	0.1	1.0130E+12	0.03	9.5461E+11
5	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.1300E+10	1.5000E+10	0.1	1.0433E+12	0.03	9.5370E+11
6	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.2239E+10	1.5000E+10	0.1	1.0746E+12	0.03	9.5276E+11
7	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.3207E+10	1.5000E+10	0.1	1.1069E+12	0.03	9.5179E+11
8	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.4203E+10	1.5000E+10	0.1	1.1401E+12	0.03	9.5080E+11
9	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.5229E+10	1.5000E+10	0.1	1.1743E+12	0.03	9.4977E+11
10	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.6286E+10	1.5000E+10	0.1	1.2095E+12	0.03	9.4871E+11
11	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.7374E+10	1.5000E+10	0.1	1.2458E+12	0.03	9.4763E+11
12	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.8496E+10	1.5000E+10	0.1	1.2832E+12	0.03	9.4650E+11
13	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	3.9650E+10	1.5000E+10	0.1	1.3217E+12	0.03	9.4535E+11
14	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.0840E+10	1.5000E+10	0.1	1.3613E+12	0.03	9.4416E+11
15	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.2065E+10	1.5000E+10	0.1	1.4022E+12	0.03	9.4293E+11
16	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.3327E+10	1.5000E+10	0.1	1.4442E+12	0.03	9.4167E+11
17	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.4627E+10	1.5000E+10	0.1	1.4876E+12	0.03	9.4037E+11
18	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.5966E+10	1.5000E+10	0.1	1.5322E+12	0.03	9.3903E+11
19	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.7345E+10	1.5000E+10	0.1	1.5782E+12	0.03	9.3766E+11
20	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	4.8765E+10	1.5000E+10	0.1	1.6255E+12	0.03	9.3623E+11
21	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	5.0228E+10	1.5000E+10	0.1	1.6743E+12	0.03	9.3477E+11
22	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	5.1735E+10	1.5000E+10	0.1	1.7245E+12	0.03	9.3327E+11
23	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	5.3287E+10	1.5000E+10	0.1	1.7762E+12	0.03	9.3171E+11
24	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	5.4885E+10	1.5000E+10	0.1	1.8295E+12	0.03	9.3011E+11
25	1.5000E+11	1	1.5000E+11	1.5000E+11	1.0000E+12	5.6532E+10	1.5000E+10	0.1	1.8844E+12	0.03	9.2847E+11

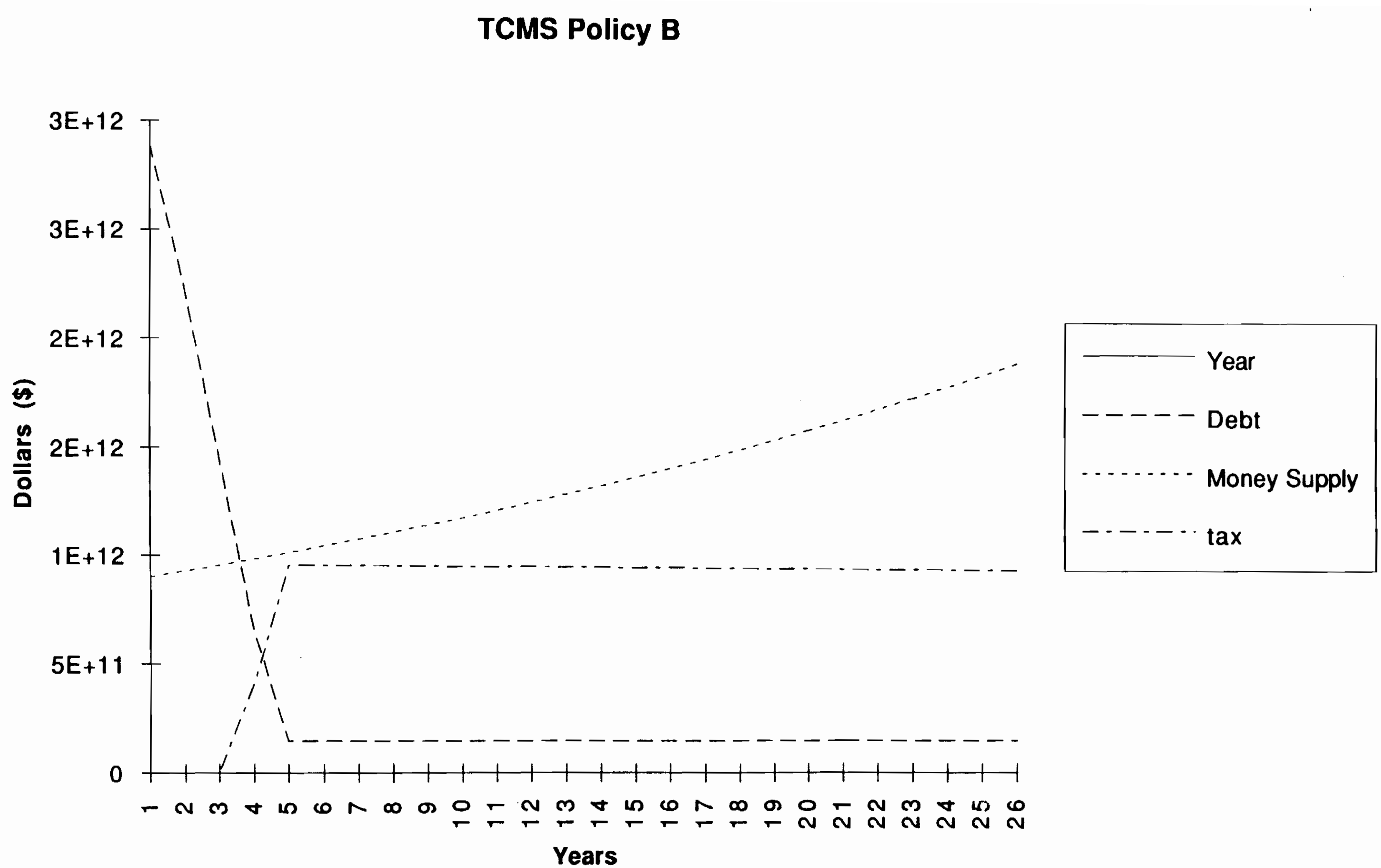

Figure 15. TCMS Policy B.

Table 10. TCMS Policy C.

Year	Debt	Δ Debt	loans	principle	exp	Δ Money	interest	intrate	Money Supply	MGR	tax
0	2.9000E+12	-5.11E+11	1.5000E+11	6.6100E+11	1.0000E+12	5.4000E+10	4.3500E+11	0.15	9.0000E+11	0.06	0.0000E+00
1	2.3890E+12	-6.0441E+11	1.5000E+11	7.5441E+11	1.0200E+12	5.7240E+10	3.5835E+11	0.15	9.5400E+11	0.06	0.0000E+00
2	1.7846E+12	-7.1204E+11	1.5000E+11	8.6204E+11	1.0404E+12	6.0674E+10	2.6769E+11	0.15	1.0112E+12	0.06	0.0000E+00
3	1.0726E+12	-8.3601E+11	1.5000E+11	9.8601E+11	1.0612E+12	6.4315E+10	1.6088E+11	0.15	1.0719E+12	0.06	0.0000E+00
4	2.3654E+11	-8.6543E+10	1.5000E+11	2.3654E+11	1.0824E+12	6.8174E+10	3.5481E+10	0.15	1.1362E+12	0.06	8.9223E+11
5	1.5000E+11	1	1.5000E+11	1.5000E+11	1.1041E+12	7.2264E+10	2.2500E+10	0.15	1.2044E+12	0.06	1.0093E+12
6	1.5000E+11	1	1.5000E+11	1.5000E+11	1.1262E+12	7.6600E+10	2.2500E+10	0.15	1.2767E+12	0.06	1.0271E+12
7	1.5000E+11	1	1.5000E+11	1.5000E+11	1.1487E+12	8.1196E+10	2.2500E+10	0.15	1.3533E+12	0.06	1.0450E+12
8	1.5000E+11	1	1.5000E+11	1.5000E+11	1.1717E+12	8.6068E+10	2.2500E+10	0.15	1.4345E+12	0.06	1.0631E+12
9	1.5000E+11	1	1.5000E+11	1.5000E+11	1.1951E+12	9.1232E+10	2.2500E+10	0.15	1.5205E+12	0.06	1.0814E+12
10	1.5000E+11	1	1.5000E+11	1.5000E+11	1.2190E+12	9.6706E+10	2.2500E+10	0.15	1.6118E+12	0.06	1.0998E+12
11	1.5000E+11	1	1.5000E+11	1.5000E+11	1.2434E+12	1.0251E+11	2.2500E+10	0.15	1.7085E+12	0.06	1.1184E+12
12	1.5000E+11	1	1.5000E+11	1.5000E+11	1.2682E+12	1.0866E+11	2.2500E+10	0.15	1.8110E+12	0.06	1.1371E+12
13	1.5000E+11	1	1.5000E+11	1.5000E+11	1.2936E+12	1.1518E+11	2.2500E+10	0.15	1.9196E+12	0.06	1.1559E+12
14	1.5000E+11	1	1.5000E+11	1.5000E+11	1.3195E+12	1.2209E+11	2.2500E+10	0.15	2.0348E+12	0.06	1.1749E+12
15	1.5000E+11	1	1.5000E+11	1.5000E+11	1.3459E+12	1.2941E+11	2.2500E+10	0.15	2.1569E+12	0.06	1.1940E+12
16	1.5000E+11	1	1.5000E+11	1.5000E+11	1.3728E+12	1.3718E+11	2.2500E+10	0.15	2.2863E+12	0.06	1.2131E+12
17	1.5000E+11	1	1.5000E+11	1.5000E+11	1.4002E+12	1.4541E+11	2.2500E+10	0.15	2.4235E+12	0.06	1.2323E+12
18	1.5000E+11	1	1.5000E+11	1.5000E+11	1.4282E+12	1.5413E+11	2.2500E+10	0.15	2.5689E+12	0.06	1.2516E+12
19	1.5000E+11	1	1.5000E+11	1.5000E+11	1.4568E+12	1.6338E+11	2.2500E+10	0.15	2.7230E+12	0.06	1.2709E+12
20	1.5000E+11	1	1.5000E+11	1.5000E+11	1.4859E+12	1.7319E+11	2.2500E+10	0.15	2.8864E+12	0.06	1.2903E+12
21	1.5000E+11	1	1.5000E+11	1.5000E+11	1.5157E+12	1.8358E+11	2.2500E+10	0.15	3.0596E+12	0.06	1.3096E+12
22	1.5000E+11	1	1.5000E+11	1.5000E+11	1.5460E+12	1.9459E+11	2.2500E+10	0.15	3.2432E+12	0.06	1.3289E+12
23	1.5000E+11	1	1.5000E+11	1.5000E+11	1.5769E+12	2.0627E+11	2.2500E+10	0.15	3.4378E+12	0.06	1.3481E+12
24	1.5000E+11	1	1.5000E+11	1.5000E+11	1.6084E+12	2.1864E+11	2.2500E+10	0.15	3.6440E+12	0.06	1.3673E+12
25	1.5000E+11	1	1.5000E+11	1.5000E+11	1.6406E+12	2.3176E+11	2.2500E+10	0.15	3.8627E+12	0.06	1.3863E+12

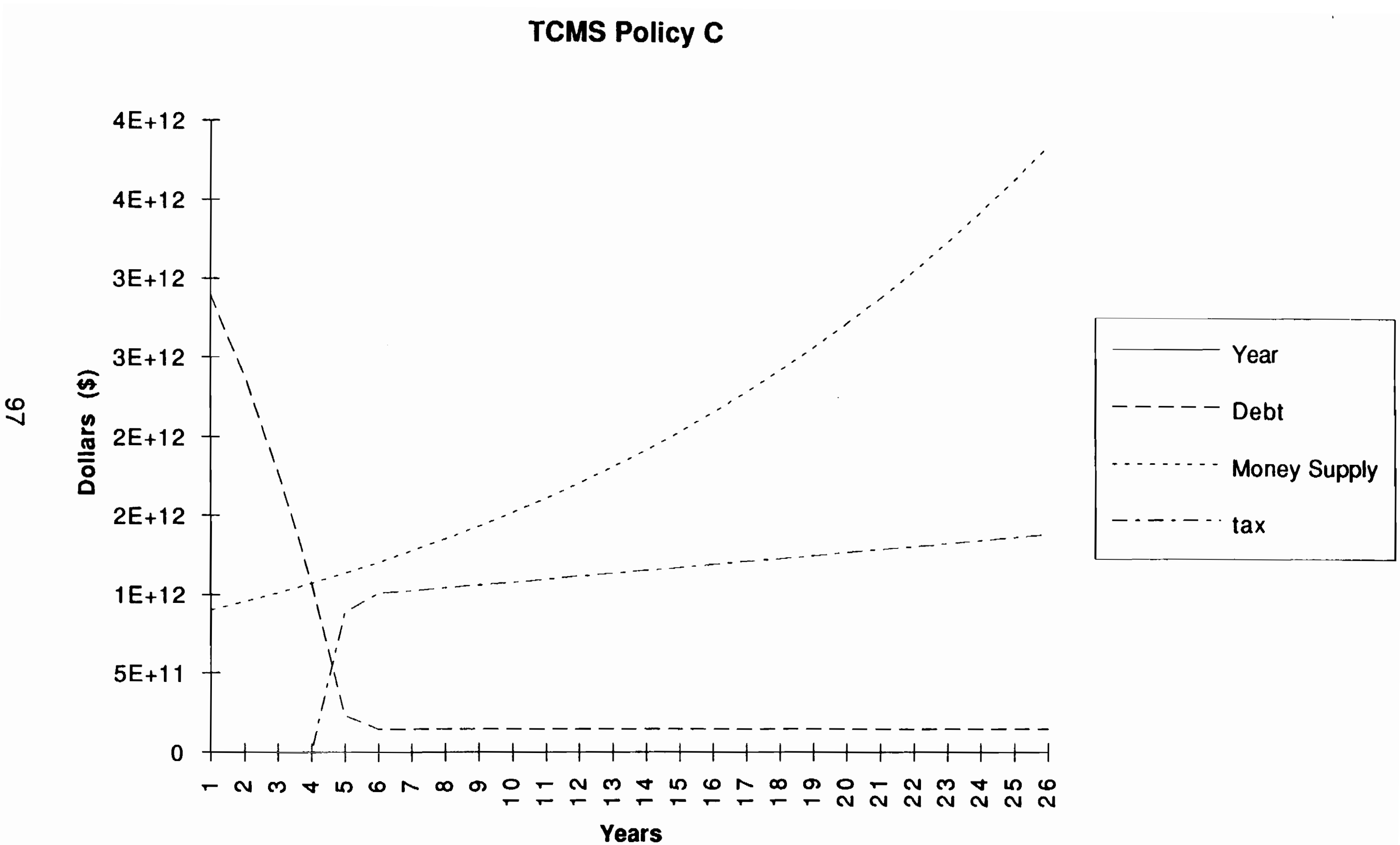

Figure 16. TCMS Policy C.

The flexibility and versatility of the system dynamics modeling technique is evident from its application to TCMS. The analysis demonstrates that the Treasury Credit Money System is an interesting and perhaps promising solution to the nation's economic problems. The analysis shown here is too simplified and superficial to draw a definite conclusion on TCMS. However, a conclusion can be drawn on the usefulness of the system dynamics methodology. System dynamics can be applied to an endless variety of S-T-E-P problems. Through the use of verbal models and causal diagrams, some unforeseen problem structures and relationships may be discovered. The analysis of the system dynamics equations adds the quantitative dimension to the technique. System dynamics is an excellent tool for economic policy analysis and formulation.

6.0 Conclusions and Recommendations

The systems engineer has a rightful place in the arena of fiscal and monetary policies. The structured, logical, top-down systems approach to problems can help the nation's policy makers analyze and solve the systemic problems of the economy.

This project proposes the use of several specific engineering tools and methods to aid the government in pursuit of solutions to our economic problems. Engineering methods provide:

- Better, more efficient control of current policy
- Capability for long-term assessment of current policy
- Tools for the formulation and evaluation of alternative policies.

The principles of life-cycle cost analysis *can* be applied to the budgetary process to ensure effective, efficient appropriations are made. Multiattribute decision analyses *can* be used to quantify non-monetary benefits. Benefit-cost analyses *can* be used to ensure that the taxpayers are receiving a benefit that is worth the cost. A systems approach to revenues *can* enlighten the policy maker on the complex chain of causality in this area of fiscal policy.

The systems approach should become an integral part of the budgetary process. The federal government should require the use of program planning and budgeting, benefit-cost analysis, multiattribute decision analysis, and life-cycle cost analysis in its annual budgetary process.

System dynamics techniques are useful in the formulation of a successful, long-term economic policy. In particular, system dynamics demonstrates that the current economic system is perilous and prone to instability. System dynamics also demonstrates the potential of the Treasury Credit Money System. The analysis presented in this project is too superficial to draw a definite conclusion on the TCMS. However, a positive conclusion can be drawn on the usefulness of the system dynamics methodology in this context.

The Treasury Credit Money System should be the topic of further research, particularly with respect to the Federal Reserve System to TCMS transition. The TCMS model presented in this project should also be expanded to show the causality of most of its constants, such as Treasury loans, expenditures, and interest rates.

The U.S. fiscal and monetary policies represent new horizons toward which systems engineers may venture. This area is not yet familiar territory for many engineers, but it is an area where engineers may make a valuable and lasting contribution to society.

7.0 Notes

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[1] Churchman, C. West, The Systems Approach, New York: Dell Publishing Company, Inc., 1968.

[2] Thoren, Theodore R., "Space-age Technology Can Correct the Money System," The Bent of Tau Beta Pi, Winter 1993, p. 20.

[3] Thoren, "Space-age Technology Can Correct the Money System," p. 23.

[4] Drew, Dr. Donald R., Class notes: System Dynamics: Modeling and Applications.

[5] Drew.

[6] Thoren, Theodore R. and Richard F. Warner, The Truth In Money Book, Chagrin Falls, Ohio: Truth In Money, Inc., 1989.

[7] Churchman, C. West.

[8] The research topic cited is a purely fictional, hyperbolic reference.

[9] Blanchard, Benjamin S. and Wolter J. Fabrycky, System Engineering and Analysis, Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1990.

[10] Blanchard and Fabrycky, p. 57,

[11] Canada, John R. and William G. Sullivan, Economic and Multiattribute Evaluation of Advanced Manufacturing Systems, Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1989, p. 11.

[12] Canada and Sullivan.

[13] Canada and Sullivan, p. 259.

[14] Automan was developed by Stephen F. Weber, Office of Applied Economics, Computing and Applied Mathematics Laboratory, National Institute of Standards and Technology and sponsored by the U.S. Navy Manufacturing Technology Program.

[15] Blanchard and Fabrycky, p. 502.

[16] Blanchard and Fabrycky.

[17] Blanchard and Fabrycky.

18 Canada and Sullivan, p. 161.

19 Thoren and Warner, p. 5.

20 Thoren and Warner.

21 Thoren and Warner.

22 Friedman, Benjamin M., Economic Stabilization Policy: Methods in Optimization, Ed. Henri Theil, New York: American Elsevier Publishing Co., Inc.,1975.

23 Cyert, Richard M., The American Economy 1960-2000: A Retrospective and Prospective Look, New York: The Free Press, 1983.

24 Cyert.

25 Thoren and Warner.

26 Thoren and Warner.

27 Thoren and Warner, p. 45.

28 Thoren and Warner, . 234.

29 Thoren and Warner, p. 73.

30 Thoren and Warner, p.105.

31 Drew, Donald R., class notes. S-T-E-P system refers to a complex system that possesses Social, Technological, Economic, and Political issues.

32 Drew, p. 21.

33 Drew.

34 Drew.

35 The model used for this analysis is adapted from Quiz A, given by Dr. Donald Drew in the course ENGR 5104, Spring 1993. Several of the constant values have been altered or varied to explore the effects of different policies or economic environments. The initial values of the level variables are the same as the model given in Quiz A.

[36] Thoren and Warner, p. 142-143.

[37] Thoren and Warner, p. 156.

[38] Thoren and Warner.

[39] Thoren and Warner, p. 219.

[40] Thoren and Warner,.pp. 223-224.

[41] Thoren and Warner, p. 281.

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Blanchard, Benjamin S. and Wolter J. Fabrycky. Systems Engineering and Analysis. Englewood Cliffs, New Jersey: Prentice Hall, Inc. 1990.

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The Bent of Tau Beta Pi. Winter 1993. p. 20-24.

9.0 Appendix

Automan Output

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Model:  NHC--National Health Care                        04/04/93

            Table 1.  Ranking of Alternatives by Overall Rating

RANK  ALTERNATIVE  RATING
=>1     Plan A      0.524  ||||||||||||||||||||||||||||||||||||||||||||||||||

  2     Plan B      0.476  |||||||||||||||||||||||||||||||||||||||||||||
```

Model: NHC--National Health Care 04/04/93

Table 2. Model Structure, Weights, Shares, and Inconsistency Ratios

CATEGORY	CRITERION	WEIGHT	SHARE	RATING INCONSISTENCY
COST	IndCost	0.667	0.210	0.000
Weight = 0.315 Inconsistency = 0.000	GovCost	0.333	0.105	0.000
BASCARAV	BasCarAv	1.000	0.404	0.000
Weight = 0.404 Inconsistency = 0.000				
SPCCARAV	SpcCarAv	1.000	0.159	0.000
Weight = 0.159 Inconsistency = 0.000				
CARECHCE	DrChoice	0.667	0.081	0.000
Weight = 0.122 Inconsistency = 0.000	FacChce	0.333	0.041	0.000

[Inconsistency of pairwise comparisons between categories = 0.004]

*Pairwise comparisons with inconsistency values > 0.1 should be redone.

Model: NHC--National Health Care 04/04/93

Table 3. Ratings by Criterion and Overall Ratings of Alternatives

CATEGORY: CRITERION	Plan A	Plan B
	RATINGS	
1: IndCost	0.652	0.348
1: GovCost	0.364	0.636
2: BasCarAv	0.565	0.435
3: SpcCarAv	0.444	0.556
4: DrChoice	0.412	0.588
4: FacChce	0.394	0.606
OVERALL RATING	0.524	0.476

Model: NHC--National Health Care 04/04/93

Table 4. Pairwise Comparison Data for Weighting Categories and Criteria and for Rating Alternatives

Comparisons between Categories

	Cost	BasCarAv	SpcCarAv	CareChce
Cost		0.900	1.750	2.500
BasCarAv			2.750	3.500
SpcCarAv				1.250
CareChce				

Comparisons between Criteria within Category: Cost

	IndCost	GovCost
IndCost		2.000
GovCost		

Comparisons between Criteria within Category: BasCarAv

	BasCarAv
BasCarAv	

Comparisons between Criteria within Category: SpcCarAv

	SpcCarAv
SpcCarAv	

Comparisons between Criteria within Category: CareChce

	DrChoice	FacChce
DrChoice		2.000
FacChce		

Comparisons between Alternatives rated by Criterion: IndCost

[See Table 5 for Performance Data]

Comparisons between Alternatives rated by Criterion: GovCost

[See Table 5 for Performance Data]

Comparisons between Alternatives rated by Criterion: BasCarAv

	Plan A	Plan B
Plan A		1.300
Plan B		

Comparisons between Alternatives rated by Criterion: SpcCarAv

	Plan A	Plan B
Plan A		0.800
Plan B		

Comparisons between Alternatives rated by Criterion: DrChoice

	Plan A	Plan B
Plan A		0.700
Plan B		

Model: NHC--National Health Care 04/04/93

Table 4. Pairwise Comparison Data for Weighting Categories and Criteria and for Rating Alternatives

Comparisons between Alternatives rated by Criterion: FacChce

	Plan A	Plan B
Plan A		0.650
Plan B		

Model: NHC--National Health Care 04/04/93

Table 5. Performance Data for Rating Alternatives

CRITERIA	ALTERNATIVES		IS HIGHE: BETTER'
	Plan A	Plan B	
IndCost	400	750	No
GovCost	3500	2000	No
BasCarAv	[See Table 4 for Pairwise Comparison Data]		
SpcCarAv	[See Table 4 for Pairwise Comparison Data]		
DrChoice	[See Table 4 for Pairwise Comparison Data]		
FacChce	[See Table 4 for Pairwise Comparison Data]		

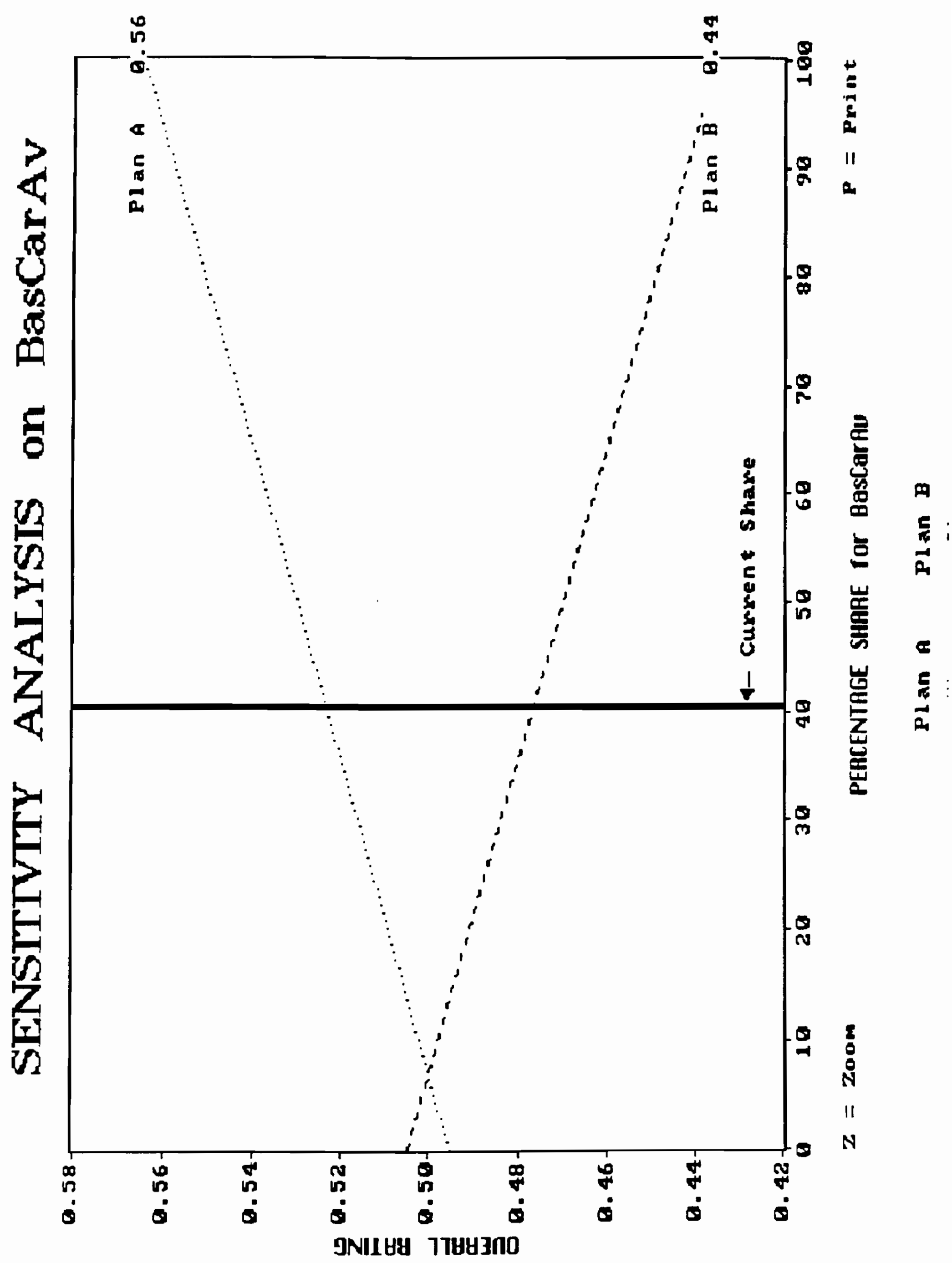

Figure 17. Automan sensitivity analysis.